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ABSTRACT

This publication resulted from the perceived need for policy makers concerned with the quality of the environment to have information beyond that limited to rhetoric and crisis oriented material. A forum in which the ramifications of long-term viewpoints could be discussed and a mechanism for continuing dialogue between policy makers and ecologists, land use planners, economists, systems analysts, and human behaviorists of all persuasions were needed. Therefore the Environmental Studies Division, Washington Environmental Research Center, Office of Research and Development invited a number of experts to present their views on alternative futures, the environment, and the quality of life. Each speaker was asked to prepare comments in one of three research themes: The Nature of the Environmental Crisis, Zero Population Growth and the Environment, and Implications of Alternative Growth Policies on Environmental Quality. This book, which resulted from the papers and discussions at the forum, is divided into two parts. Part 1, Challenges of Alternative Futures, reviews the environmental and population issues, presents a recent systems method of analyzing the problems of growth and summarizes the international implications of growth policy. Part 2, Coping with Alternative Futures, presents human behavioral factors and their influence on growth policy. Classical and modern concepts of economics and implications for growth policy conclude the work. (Editors/PEB)

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## WORKING PAPERS IN

# ALTERNATIVE FUTURES AND ENVIRONMENTAL QUALITY

*AUGUST 1973*

*REVISED*

*NOVEMBER 1973*

ENVIRONMENTAL
PROTECTION
AGENCY

**Office of Research and Development**
**Washington Environmental Research Center**
**Environmental Studies Division**

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## *FOREWORD*

The quality of the environment is now a major policy issue for government and industry officials. Policy-makers also find an emerging quality of life ethic among the public resulting in ever more persistent articulation of a desire for a higher standard of living, more freedom of choice, more leisure and more personal fulfillment.

The overriding concern for the environment arises from the increasingly visible signs of air pollution, water pollution, waste accumulation, noise pollution and contamination by toxic substances resulting from how we do things today. There is often great pressure for short-range, immediate solutions to problems. Short-term plans and the means employed to achieve these objectives are sometimes implemented without adequate consideration for the possible long range environmental degradation which may result.

What is needed, then, to complement immediate action programs is a policy assessment process involving analysis of long-range pitfalls and potentials.

For example, the Bureau of the Census recently reported that the population growth rate in the United States has been decreasing to the point which will eventually produce zero population growth. Does this mean that the population will not reach the higher numbers forecast only a short time ago? Does it mean that contingency planning being done today which is sensitive to population fluctuations will require some modification? Would, for instance, a smaller population be expected to produce less pollution and solid wastes? Demographers tell us that family units having fewer children, or children at a later time in life, which is indicative of zero population growth, results in a greater number of women willing and able to work. The first order effect of zero population growth, they tell us, is expected to be a greater number of people in the work force. Does the combination of greater business capacity and higher per capita income, produced by this eventuality, produce a greater pollution and solid waste problem than would initially be expected from a declining population growth rate?

When faced with these questions, the policy-maker finds limited information available. The more rhetorical and crisis oriented information tends to be most available and tends to pervade the consciousness of the public and of public officials. Thus, there appears to be a need for a forum in which the ramifications of long-term viewpoints can be discussed. We need to establish a mechanism for continuing dialogue between policy-makers and ecologists, land-use planners, economists, systems analysts, and human behaviorists of all persuasions.

What, then, are the full policy implications of zero population growth; of the newly evolving environmental ethic; of new economic concepts which span from rental economics to expanded ownership patterns?

It was in this spirit that the Environmental Studies Division, Washington Environmental Research Center, Office of Research and Development invited a number of experts to present their views on alternative futures, the environment and the quality of life. Each was asked to prepare comments in one of the three following research themes. The Nature of the Environmental Crisis, Zero Population Growth and the Environment andImplications of Alternative Growth Policies on Environmental Quality. The invited authors are listed following this foreword. The Topic area assigned each author, which became titles of papers produced for possible presentation at a symposium is reproduced in the appendix.

As initially planned, it was thought that this research project would utilize a symposium as the vehicle to elicit comment and response from a representative cross-section of governmental officials having decision-making responsibilities affecting the future. However, it soon became apparent that the complex web of ideas being generated within any one of the three theme areas was too much for one group of individuals at one sitting. Consequently, it was thought that a more appropriate tactic would be to produce this volume expressive of the kind of dialogue needed to assist policy-makers develop comprehensive perspectives for assessing future needs and priorities on a continuing basis.

Stanley M. Greenfield
*Assistant Administrator*
*for Research and Development, EPA*

August 1973

# PREFACE

Early in the organization of the Environmental Studies Division (ESD), a branch was formed to conduct research of an exploratory nature. This Branch had as its objective:

> "To extend the time-horizon for policy analysis" and further to build "upon recent advances in the state-of-the-art in the development and application of approaches for generating and studying alternative futures."

One of the first projects undertaken by this branch was an EPA Symposium on the Quality-of-Life (QOL) Concept which was held at Airlie House in the late summer of 1972. As interest by the social science community grew in the symposium during its planning phases, ESD staff thought it desirable to undertake a series of inter-disciplinary study seminars as a part of its work program to reinforce the interest generated in QOL and other closely related subject matter.

Topics suggested for the seminar series ranged from environmental management to questions of aesthetics. Lying somewhere between were topics concerning: land-use carrying capacity; the nature of the environmental "crisis" and development of indicators of environmental quality. The latter topic was eventually researched in-house and included as a part of the QOL Symposium.

As a lead-in to the seminar series ESD had been given tentative approval to fund an EPA publication to be entitled "Environmental Issues and the Social Sciences." The purpose of the project was to engage a number of respected authorities in a wide range of disciplines to:

> "... focus on the expected contributions that social scientists may offer to: (1) a better understanding of how to go about managing our existing environment (both natural and man-made) and (2) a process for creating desirable alternative environments for the future."

The "Environmental Issues and the Social Sciences" book project undertook several turns of events to become the publication you, the reader, now have in hand.

Ideas and suggestions contained in the three theme areas mentioned in the Foreword are reflected in the six Chapters of this book. Portions of each contributed paper were used, as appropriate, to explore as full a range of opinion in each area as possible. The charge given the editors was to present in dialogue fashion for each area: the classical concepts and trends; new concepts and possible trends and implications for growth policy. Generally the introductory material prepared by the staff is identified within the text by horizontal line separations.

This book is divided into two parts. Part One, Challenges of Alternative Futures, reviews the environmental and population issues, presents a recent systems method of analyzing the problems of growth and summarizes the international implications of growth policy. Part Two, Coping with Alternative Futures, presents human behavioral factors and their influence on growth policy. Classical and modern concepts of economics and implications of economics for growth policy conclude the work.

The book was written for policy-makers and planners at all levels of government in the hope that the most recent thinking on population, environment and economic growth can be diseminated to initiate discussion and dialogue and to expand the information base on which decisions are based. We have many "alternative futures"; we seek alternatives which preserve the environment and improve the quality of life.

John Gerba

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# PART I

# CHALLENGES OF ALTERNATIVE FUTURES

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# I

The "challenges of alternative futures" encompass the problems of providing a high quality of life with minimum environmental degradation to a growing population tending to cluster in crowded urban areas and requiring industrial, economic and technological growth.

In Part 1 several aspects of population and environment are discussed from several viewpoints. The Nature of the Environmental Crisis is defined in Chapter 1 from a viewpoint of ecological balance and stability. Seven ecological principles are proposed and their implications for broad goals and policy are outlined. Present activities of the Federal government in managing the environment are reviewed; the need for economic incentives complementary to and supporting regulation is discussed. The control of pesticides is reviewed; recent information on decreasing residues of DDT found in several test programs are presented leading to the author's conclusion that, with more complete information now available, pesticide regulation might take a different course.

In Chapter 2 the Implications of Zero Population Growth (ZPG) are discussed from several viewpoints. Recently the United States birth rate has been decreasing and is currently below the replacement rate. Thus a Zero Population Growth rate has been achieved. However, the population will continue to grow in absolute numbers and trends to urbanization resulting in densely populated areas will continue. Therefore population growth will continue to be a problem for national and regional planners and decision-makers.

In the Chapter current population forecasts are reviewed, reasons for the declining fertility rate are presented and one contributing author concludes that the rate will remain near its present value. He presents social, cultural and economic reasons for his conclusion. The effects of population growth on the environment under conditions of ZPG are reviewed first using a single model to illustrate relationships, then presenting the results of a more complete study.

In conclusion policy alternatives for achieving an improved quality of life and environment are reviewed. Direct methods, i.e. specific pollution control, planned land use and similar procedures are shown by this author to be superior to less specific goals such as "zero growth".

In Chapter 3 an Analysis of Ecosystem Capacity is presented. The paper from which this material was taken presents a first attempt at applying an analysis of carrying capacity to a region. First approximation numbers are developed for the Pacific Northwest as a specific example of the technique.

The author's methodolgy includes the following steps: 1) establish a benchmark quality of life standard (per capita income level and apportionment), 2) determine the capacity of resources in the region to supply material goods, 3) determine the capacity of resources in the region to supply amenities (measured as recreational land available), 4) quantify the variation of environmental quality as a function of population numbers and 5) evaluate alternative combinations of population and pollution control by comparing the quality of life and regional capacity obtainable for each alternative. The author concludes that the approach is viable, given more research and information. He recommends that this analytical tool be used to support policy and planning analyses; he suggests that full dissemination of information to the public, development of public conception of goals, effective land use and energy use and control are essential to long-range improvement of the environment.

In Chapter 4 the International Implications of Growth Policy are summarized. The international dimension of environmental policy is discussed from two viewpoints: 1) constraints of freedom of national action imposed by international realities (i.e. oil importation) and 2) the effects of alternative national growth policies on the world structure. Clearly, the international dimensions of growth policy must be incorporated in planning at the outset.

# I

# NATURE OF THE ENVIRONMENTAL CRISES

## *Introduction*

Planners and decision makers at all levels of government and industry are faced with the reality of pressure from the public to improve the quality of the environment and the quality of life. This demand comes from a general awareness of the degradation we inflict on our surroundings and from a fear we may destroy ourselves if degrading trends are not reversed. Concern for quality of life stems from an increasing emphasis on human and social values. National, state and local policies must allow for these considerations.

Quality of life is as difficult to define as happiness. It is highly subjective and the concepts change with time. Attempts to define and measure quality of life center on enumeration of economic, social, aesthetics, psyschological and environmental factors generally agreed to affect quality of life. It is clear than a quality of life ethic has become deeply engrained in our society and that a growing demand for improving and maintaining the quality of the environment is a principal component of that ethic.

Nearly everyone knows that ecology is the science dealing with the relationships between organisms and their environment; that the biosphere is that portion of the earth and its environment within which life is contained. Nearly everyone perceives that all things in the biosphere are interrelated and form a complex ecosystem. Everyone understands, to some degree, that the environment includes not only the physical reality surrounding man but that man himself is an integral part of the environment. Indeed, he is the only part able to willfully modify the environment. Everyone has heard of the "environmental crisis" and the "population explosion." Most are concerned about depletion of natural resources and many question the potential effects of "uncontrolled technology."

Divergent views are held regarding the nature and extent of the environmental crisis and what should be done about it. Some believe we have already set in motion irreversible processes degrading the environment beyond its capacity to sustain life as we know it. Others hold that "crisis" statements are made only to attract attention and to gain public support for environmental management to assure that the crisis stage is never reached.

Some hold that the concept of crisis itself is a dangerous illusion—we will never reach a turning point after which unalterable degradation or dramatic improvement will be realized. Instead we are faced with a slowly (lately more rapidly) evolving change which must be controlled by continuous hard work. Some put economic growth and other values above quality of life and quality of environment and are unconcerned about environmental degradation. Some feel technology will find solutions to most of the problems before they become critical.

This range of viewpoints exists because we are really quite ignorant about many of the relationships between population, economics, technology, and the environment. In the past economic growth has been emphasized not knowing at what expense it caused qualitative growth. The social cost of environmental degradation has nowhere been accounted for adequately. The environment as a comprehensive system with interdependent parts, including man, has hardly been perceived. Environmental considerations hardly entered the policy and decision process.

This report presents discussions of the major environmental issues, taken from invited papers and other sources. In this Chapter current environmental policy and management are reviewed and an opposing viewpoint, questioning whether we are guilty of over-control is presented. This discussion illustrates the need for more information, more research, better understanding and the need for a comprehensive conceptualization—models, methods of analyses and unifying systems concepts—to better analyze and evaluate environmental policy.

Subsequent Chapters will cover population growth and the implications of Zero Population Growth, the application of carrying capacity analysis to regional planning, the international implications of growth policy, and the relationships between growth, economics and behavior.

## *Elements of the Environmental Crisis*

The principal elements contributing to our environmental problems are population, degradation of the physical environment, changing technology, and economic growth.

The National Goals Research Staff summarized the principal issues as follows:

### Population Issues

The traditional view of population growth as a source of national pride and strength is being re-examined. Some authorities argue for zero population growth on the grounds that population stability is imperative for survival, or will improve the quality of our society. (For example, it might enable us to avoid the issue of limitations on the use of energy and materials.)

The merits of sheer size now appear more debatable than heretofore, particularly in the case of large metropolitan areas. Large concentrations of population generate serious pollution problems, traffic congestion, and higher per capita public expenditures. And they are unduly vulnerable to power failures, riots, and other disruptive social action. Thus, major questions are asked: should we limit our population size, and if so, how? And should we redistribute our population, and if so, how?

### Environmental Issues

Historically, our concern over resources focused on whether there would be enough food, energy, and materials to meet our needs. Today, in the United States, the concern is about the ability of land, air, and water to absorb all the wastes we generate. We already have violated the aesthetic limits of pollution and, from time to time and place to place, we have violated health and survival limits of pollution. Some argue that the long-run issue may well be our survival. Questions often asked are: What can be done to repair the damage already done? To what extent and by what means will future pollution be contained within tolerable limits? Are there fixed limits of environmental tolerance that might make it imperative to limit the size of our population or set per capita quotas on the amount of energy and material we may use?

### Technology Assessment

Technology is becoming both more voluminous and more complicated. The complexity of much new technology makes it more difficult to anticipate how it will do its primary job and what its second-order consequences will be. As our understanding of biological, ecological, economic, and social processes improves, we are struck with the complexity of the consequences which technology can produce. We have a growing determination and belief in our capacity to evaluate the second-order consequences of all our actions including the use of technology, and to include their costs in our policymaking process.

**Economic Issues**

In the past, the air and water have been readily available for any purpose. Our production and consumption activities could be carried out without particular concern for conserving our natural gifts.

But as production and consumption have risen (along with population) more and more impositions have been made on the air and waters. These incursions are the consequences of economic growth and the notion that the environment is available at no cost for whatever use we want, including that of disposal of the wastes from economic activity. Thus, when we impose on our air and waters in ways and amounts that use up these necessities, we levy a real social cost. These resources are no longer free to society.

Because private use of the physical environment is available at no cost, the market system which allocates resources operates imperfectly. To attack pollution requires a balancing of the costs of imposing on the environment with the economic benefits obtained from the associated production and consumption.

## *Definition of Environmental Crisis*

The following definition and discussion of the environmental crisis is taken from the invited paper prepared by Bettie Willard, a member of the Council on Environmental Quality. She defines the term environmental crisis, reviews the fundamental principles of ecosystems, and presents recent examples of ecological problems and man's response. She suggests general strategies which can be implemented to deal with the problems.

The definition of an "environmental crisis" is:

1. An imbalance among the physical, chemical, and biological elements

and/or processes of an ecosystem that threatens the vitality and productivity of some or all species of the system.

2. A disruption of a biological system to the point where it no longer can support some or all the organisms in it.
3. A reversal of ecological processes of an ecosystem to a point where several to many generations are required to restore the productivity, complexity, and stability of the system.

### The Rhetoric of Crisis

Much of the rhetoric about an environmental crisis is being used in an attempt to awaken man to his relationship to the environment and to his responsibility for being sure we approach no nearer a threshold, beyond which there is no return. Man assumes this responsibility a little by default, in that he, by his nature, is the only species on the earth that can remember and transmit complex knowledge. This feature of man makes him capable of forecasting the future in some limited ways, based on observations arising from the past. Because he has this ability, it is incumbent on him to use it in constructive ways.

The important thing to realize about an environmental crisis is that we do not want to reach the point where we actually have one of any magnitude. I think we can all see that we have had one of minor magnitude in some of the waterways and urban areas of our Nation. Fortunately these problems have not reached major proportions yet. But we do not, *under any condition*, want to reach the point of the major environmental crisis. The price is too high—massive famine, extensive disease, stark landscapes, degeneration of civilization as we know it. Therefore, why all this talk of environmental crisis, when we have not yet experienced one?

I should like to draw two analogies, to illustrate why we are using the term:

1. In training children about hot stoves, poisons, cars, cliffs, etc., we make the situation imperative because we know the consequences and do not want the person to reach the point of crisis.
2. As adults we make budgets of time, materials, labor, money, because we know the consequences of not doing so. Again we are unequivocal in our approach, as a preventive rather than curative thing.

In each of these cases, the dire results of negative action are clear before the adult mind. That clear picture motivates positive clearcut action.

### Examples of Response to Environmental Problems

Now, in the case of "environmental crisis," the dire results of the *trends now in motion* cause ecologists who see these consequences clearly, to use the term "environmental crisis" to get attention and motivate people positively. For example:

1. Soil erosion in the early 1900s led us to take positive action to establish the Soil Conservation Service.
2. Exploitive forestry "practices" at the turn of the century led to the establishment of the U.S. Forest Service and adoption of more advanced, long-range forest practices from European countries.
3. Overgrazing in the West resulted in the Taylor Grazing Act and in wise wildlife management practices, such as carrying capacity.
4. The Kaibab deer herd die-off in the 1920s caused us to accept the role of predators and to determine the carrying capacity of the range.

**Principles Governing Ecosystems**

Ecosystems, of which we are an integral part, are governed by the following principles:

*First*, everything affects everything else. The more we learn of the ecosystems of the earth, the more we realize the truth of this principle. Never have we found evidence to the contrary. For example, just try to find a biological sample from pole to pole without DDT or radiation in it. And how did it get there?

*Second*, all living things exist as part of systems composed of physical environmental factors—climate, soil, exposure, etc.; organisms; and the processes that operate among the organisms and environment factors. Also each species of living thing has a specific role to play in the ecosystem.

*Third*, in each system there are factors that limit the growth, reproduction, or activities of some or all the species; therefore the distribution of species is determined by these physical and chemical parameters interacting with the nature of the species.

*Fourth*, each system has a definite capacity to carry the organisms of that system, determined both by the physical features of the environment and the nature of the biological components.

*Fifth*, in these systems all materials cycle—are reused, but the energy of the systems flows in one direction—downward to uselessness.

*Sixth*, as specialization develops in a system, diversity increases; and as diversity increases, stability of the system increases.

*Seventh*, all surfaces of the earth are either in varying stages of development toward stability or at the permanent ecosystem for a given site for the present conditions of climate.

As we examine these principles in light of their meaning to human ecology, we find that man has rejected these principles as being not applicable to him. He has, after all, demonstrated dominion over lack of food, over fluctuating climate, over disease. So these principles obviously do not apply to him—only to those other organisms less fortunate than he. This is where and how he has created a potential short-or long-range ecological crisis. *For he is a part of the systems to which these principles apply,* whether he accepts the fact or not. And his overlooking of these principles has precipitated potential or actual ecological crises of varying magnitudes.

## Examples of Environmental Crisis

To emphasize this point, to get man's attention focused on the problem before it is too late, ecologists have talked of "environmental crises", they have talked of "our plundered planet" (Osborne, 1941), of a "road to survival" (Vogt, 1941), a "land ethic" (Leopold, 1945) and an "ecological conscience" (Sears, 1937). They have even spoken of a "silent spring" (Carson, 1962) in efforts to awaken man to the neccessity to take his niche—his role *in* the ecosystems, not *over* these systems.

At this point in time, it behooves man to quickly bring himself into conformance with these principles. An ignominious end may await man—not an end to the ecosystems of the earth, which have the potential to survive the crisis. After all, man is the first organism, so far as we know, that has the quality of rational thinking accompanied by memory and transmittal of knowledge. This unique ability carries a special responsibility that it be used for the benefit of all of the earth.

To implement man's conformance with the ecological principles outlined above and to measure his degree of harmony with his ecosystem, we need a variety of monitoring systems. We need to know the limiting factors operating and how close we are to reaching them. We need to know the level of energy consumption and what types of uses consume less. We need to know the carrying capacity of ecosystems for man and his processes, as well as for deer, elk, cows, sheep—and how close we are to maintaining or exceeding this capacity. We need to augment the conscious cycling of materials and to know better how these cycles affect the ecosystems. We need to favor stability and diversity and know that we are. Some of these monitoring systems are in use now. Some we will need to devise.

To bring portions of the system into balance with other components, we need to use pollution control devices. These are best designed to accomplish the balancing in the way the system always has. For example, spray irrigation for land disposal of sewerage, rather than river disposal.

All terrestrial organisms but man dispose of their organic wastes on land—trees drop leaves and fruits—animals defecate on soil—all of which returns nitrogen, carbon, phosphorous to the material cycles in a short time.

But man sends his wastes out to sea to be made into rock to be mined by some as yet unknown organisms in eons to come, thus enforcing his own need to mine more of these substances to return to the land from whence he has taken them as food or fiber. A cycle of incredible magnitude and no known utility!

Let us examine a few major environmental crises of recent years. Well-known, but highly instructive is the Aswan Dam situation in which several major imbalances were triggered by the closing of the dam:

1. Change in nutrient balance throughout the Nile Valley, traditional to the productivity of this valley for literally thousands of years, by collecting of sediment in Lake Nassar that once yearly fertilized the valley.
2. Change in nutrient level in the Mediterranean, lowering the productivity of invertebrate fish food (shrimp), therefore of fish (sardines).
3. Change in soil moisture, allowing one stage of a parasite carrying schistomyosis to develop and invade man which before had been controlled by the periodic flooding, leading to major disease in the population.

Therefore, what was intended as a great blessing to the Egyptians as a source of power and controlled irrigation water, turned out to be a serious detriment to food sources and the health of the nation.

Could this have been predicted and averted? Yes, definitely, but so doing would have required one to several years of intensive ecological research of the natural systems inhabiting the area to be affected. The technology to accomplish this research existed. The desire to know and use it was lacking.

A second and somewhat less dramatic example of environmental crisis is represented by fire control practices in the Western United States. It has recently been discovered that fire protection allows tinder to build up in stands, so that when a fire does occur, the destruction is many times greater than if the fire had been allowed to periodically clean out the tinder. Also with fire protection, some valued tree species, such as sugar pine and giant sequoia, are overgrown by less valued trees, such as incense cedar.

A third example was cited above—when man protected the Kaibab deer of Grand Canyon from their life-long predators, they increased their numbers by 25 percent per year, soon to eat themselves out of house and home. Having devastated their range, they died of starvation in large numbers. Some favor we did them!

So it is with man's not-so-infinite wisdom. He frequently turns out to be much more like a bull in a china shop, not recognizing or obeying the timeless principles that have operated to keep the systems that have spawned him operating in a dynamic equilibrium. As Lynn White points out, man's complex of "having dominion" over everything has provided the roots of our ecological crisis. Man has interpreted "having dominion" as having the right to exploit, desecrate, destroy as he pleased. And now he is awakening to the results of his actions, potential ecological crises.

Man has long believed, and with some justification, that any change he brings to the natural system will be beneficial. At first, this was true. The development of agriculture and the domestication of animals both enabled man to be free of the need for hunting and to use this time for cultural pursuits. The construction of houses and the use of fossil fuels to heat them enabled man to leave the cave.

Why did this awakening not happen earlier? Mainly because the systems are capable of absorbing some abuse without changing drastically. Also, in 1969 two events made him see these systems more clearly. The Santa Barbara oil spill and the landing on the Moon made him realize dramatically how tenuous but important is that thin film of the Earth's biosphere. Now these changes are showing cumulative degradation—trends which, if not reversed, could lead to destruction of the race. Not a violent, catastrophic destruction, but a slow, painful, whimpering destruction.

## Application of Ecological Principles

When man applies the principles of ecosystems the results are strikingly good. For example, when the limnologists at the University of Washington realized the downward trends in motion in Lake Washington due to sewage outfall into the lake, they designed a method of sewage disposal to bring the system back closer to its original pre-man functioning. The results were a dramatic return to a healthy ecosystem within three years.

A second example is the Pribiloff seals which, when protected against hunting pressure during the crucial mating period and rearing of young, made a significant comeback in population numbers. Similar examples can be seen with several other rare and endangered species.

Thirdly, western ranges that have been managed at or below their carrying capacity for cattle, deer, elk, have shown amazing recovery to their once high productivity.

Seeing how quickly and dramatically results of obeying ecological principles can occur, let us now examine each ecological principle in light of some things man can do now to implement that principle in his activities.

*First principle:* If everything we do affects everything else, we need to trace out the direct and indirect effects accurately, so as to know how to modify action adequately and accurately. Examples are in DDT and phosphate, where we have only been concerned with the primary effects—dead pests and clean clothes, without looking at the secondary, tertiary, etc., effects of these substances in the pathways they follow in the ecosystems of the world.

Stopping phosphates in the ecosystem can be equally or more devastating than too much, as phosphate provides an essential component to transfer of energy in all biological systems.

The National Environmental Policy Act of 1969 is causing agencies to have to answer these questions and many more—at least in part. This is a vast improvement, for even without all the answers, seriously addressing the questions is a sobering experience that usually leads to more conservative action. More needs to be done.

Sometimes when we do find out where materials are going in the systems with which we are dealing, we discover a natural pathway that protects man from the harmful effects, thus we can put the pathway to use consciously. A beautiful example of this is in the cypress swamp bordering the Savannah River, downstream from the large AEC test reactor. This swamp was left intact to separate the reactor visually from the surrounding area. Recently it has been demonstrated that the swamp is a perfect sponge, absorbing all radionucleides in the waters issuing from the reactor. But other pathways need to be researched and then designed to build in effective buffers. We cannot assume we will have such a simple situation in every site.

*Second Principle:* Not recognizing that all organisms play a role in systems we sometimes remove one component (a predator) to benefit another component (sheep) while severely putting out of balance the rodent population, so they eat the grains and herbs to the detriment of the sheep. By this same attitude we could easily have deprived ourselves of an ugly dirty bread mold—penicillin! We need to research the life cycles of all organisms and to understand better what role they are playing in the whole scheme of things.

*Third Principle:* Knowing of the need for dry climate in the maturing of dates, man brought the All-American Canal system to Coachella Valley and along with it, a climate much less favorable for its prime cash crop, dates, while also bringing water for a lesser cash crop, truck farming. Thus the limiting factors of two organisms clashed to the detriment of the farmers' income.

Also, not wanting to admit that where one flood has been, another will be, we continue to build expensive structures in floodplains, then expect the taxpayers of the Nation to support the construction of protective structures to partially obviate the situation, instead of assisting people in relocation of these structures and development of conforming uses of the floodplain.

We need to investigate how to integrate man's activities with the processes of existing systems—to utilize the potential of the existing systems, rather than altering them beyond recognition and to our detriment.

*Fourth Principle:* Believing that we can graze as many cattle on an area of land as can stand on the ground, we alter the productivity of grasslands.

sometimes totally, so they are no longer grasslands but desert scrub. We do the same thing with businesses and industry, believing that space is the only determinant to carrying capacity, not demand, critical ecosystems, operating ecosystem processes and neighborhood needs. We need to study carefully, with a systems approach to determine the carrying capacity of various systems for the activities we wish to impose on them. Once these capacities are known, we need to function within them.

*Fifth Principle:* Oblivious of the natural cycles of materials, we dispose of our wastes in such places and by such manners as to achieve a linear rather than cyclic pathway for the materials. Also, since higher consumption of energy is rewarded by lower prices per unit, we hasten the end of fuels by a price structure and use pattern that is against the natural energy conservation modes. Also, we do not analyze how some substances move in the system, so awaken with surprises like the release of mercury by the burning of fossil fuels.

Knowing that such things can happen should alert us to tracing out all pathways of materials in our environment, especially such substances as cadmium, plutonium, and arsenic that are potentially damaging to the living system in small quantities. Also, the pending energy crisis should propel us to use energy in the most efficient manner possible, and to use renewable sources over nonrenewable sources. For example, in Miami homes that once had solar water heaters had recently abandoned them in favor of the "all-electric home". What a tribute to Madison Avenue!

*Sixth Principle:* To accommodate mechanical harvesting devices and desire for crops of uniform structure and performance, we abandon systems of diversity, only to wail and moan when such systems are not resilient to slight fluctuations of climate, etc. We need to evolve systems of agriculture that have both diversity and high performance, and are resilient because of their diversity.

*Seventh Principle:* Forgetting the decades, centuries, even millenia it takes to develop ecosystems, we scrape them off with abandon, only to wonder what happened to our clear fishing streams and animal populations. We need to be as expert at transplanting or restoring ecosystems as we are at eliminating them. The Germans strip-mine property and return the property to its owner with guaranteed 25 per cent increase in productivity. Why can't we?

Instituting these and many other ideas ecologists abound with will begin to bring man into his niche as a member of the community of life and to alleviate the ecological crisis. But it takes practicing the "land ethic", using our "ecological conscience".

Early efforts at managing the environment were hampered by a lack of understanding and information regarding the ecosystem. Bettie Willard summarizes these problems as follows:

> *Compartmentalization* of action and legislation:
>
> —forests are dealt with in Agriculture
> —fisheries are managed in Commerce and Interior
> —soils are managed in Agriculture
> —wildlife are managed in Interior
>
> The closest we come to managing whole ecosystems is the National Park Service. Nor are data integrated anywhere centrally. So little wonder we get no holistic policy-making or decisions.
>
> *Homogenization* of application of standards, management practices, fundings, with little or no recognition of the differences in processes operating in different ecosystems, regions, communities. After all, individualization is a basic American tradition, but we forget it frequently, when dealing with the environment.
>
> *Fractionalism* of efforts to alleviate environmental problems:
>
> —set air standards with little look at where pollutants will go, once captured (perhaps to make dirtier water or land);
>
> —develop water law with no concern for the fact that water is integral to the land on which it arises and flows;
>
> —manage agriculture solely from a political and economic point of view, not from the standpoint of where crops grow best and with the minimum of disruption and expenditure of energy, money, land resources;
>
> —manage resources in a linear, rather than a cycle fashion—have goods and material always eventually destined to the junk heap and using valuable land for that!
>
> —using energy and resources as though they were infinite and eternal;
>
> —appropriate funds on a short-term base for long-term management; then change horses in mid-stream, forgetting that the objects being managed have a longer lead-time for adaptation than we have given them. We can all learn valuable lessons in policy-making from systems analysis and use of what such analysis tells us.

In 1970 these problems were attacked and the Federal environmental program organized and consolidated with the passage of the National Environmental Policy Act of 1969 which defined national policy and created the Council on Environmental Policy in the Executive Office of the President. Later in 1970 the Environmental Protection Agency was formed to consolidate federal activities in pollution, solid waste disposal, pesticide regulation and environmental radiation.

## The National Environmental Policy Act of 1969

The National Environmental Policy Act of 1969 (NEPA) established a national environmental policy and created the Council on Environmental Quality in the Executive Office of the President.

The major requirement of NEPA was that all Federal agencies be required to include in all proposals for legislation and other major activities an environmental impact statement summarizing the environmental effects of the action. Since its inception the courts have held the environmental impact procedure is court enforceable upon citizen suit. The best known citizen action involved the proposed Alaskan pipeline.

The Council on Environmental Quality was established to develop and recommend national environmental policy to the President, to conduct studies, review programs and to assist in preparation of the annual Environmental Quality Report, required by the NEPA.

## Activities of the Council on Environmental Quality

Shortly after the Council was established, the Office of Environmental Quality was formed (Environmental Quality Improvement Act of 1970) to provide staff to the Council. Later by Executive Order the Council was empowered to recommend priorities in environmental programs to the President and Federal agencies. The Council began to encourage the development and use of environmental quality indicies and monitoring systems.

The Council has been active in projects such as nonpolluting power sources for automobiles, solid waste management, pollution control, pesticides, control of toxic substances, reduction of pollution by Federal facilities and land management.

## The Environmental Protection Agency

EPA was established in December 1970 and consolidated into one office the major Federal programs dealing with air and water pollution, solid waste disposal, pesticide regulation and environmental radiation. As an operating line agency. EPA is responsible for the conduct and administration of Federal pollution control programs.

EPA established national air quality standards, established a framework for state establishment of emission standards and enforces the provisions of the Clean Air Act. EPA also administers the 1975-76 auto emission standards program, regulation of gasoline additives, other motor vehicle pollution regulations and is supporting research on development of a clean car.

EPA also established and enforces water quality standards through the Federal Water Pollution Control Act and the permit provisions of The Refuse Act and conducts air and water quality monitoring programs and research.

Control of pesticides is maintained through the registration provisions of the Federal Insecticide, Fungicide and Rodenticide Act. EPA issued notices of cancellation of all DDT and other persistent pesticide registrations.

In the area of solid waste management the Resource Recovery Act of 1970 requires EPA to publish guidelines for construction and operation of solid waste systems and to develop methods for disposal of hazardous wastes. Many open dumps were closed and replaced with improved disposal systems.

Other EPA activities include cleanup of federal facilities, control and regulation of toxic substances, setting air-water ambient radiation standards and the study of noise pollution. Basically, then EPA has functioned as the federal environmental regulatory agency.

## Economic Incentives and Regulation of Pollution

Pollution control requires regulation and enforcement. There is growing recognition that regulation alone, without economic incentives is not the optimum approach and is difficult to implement. A recent commentary by Stanley M. Greenfield, EPA's Assistant Administrator for Research and Development states the case as follows:

> A purely regulatory system leaves pollution itself cheap while effective control is expensive. Therefore, the firm or industry or municipality which is best able to delay having effective abatement forced upon it will gain in the market. Among firms in an industry, the first to develop an effective but expensive control technique for itself risks being forced by the regulatory agency to apply it. Because availability and reasonableness of technology is determined on a plant-by-plant basis, in legal fact if not in legislative or administrative theory, the hapless innovator is likely to find that his competitors escape with much less costly actions unless his new techniques

are applicable and available to them; a polluter has little to gain and much to lose by being first to develop a new, more costly technique.

The same principles hold for industries in an economy. For example, if the copper smelters develop and have forced upon them expensive control measures, copper loses relative to aluminum in the electrical conductor market.

In a regulatory system, the strongest incentive for research and development by the polluters is the need to defend themselves against charges that technology is available but they are not using it. In court, an excellent defense is to demonstrate that major efforts are being made but that technical difficulties have not yet been overcome. This type of research and development effort also allows the polluters to produce a good fall-back position: after much work, they can say that it is technically impossible to reach the original control target, but they now are going ahead with construction of a compromise technique which is the best currently possible.

Until we have some measures of true total costs and total benefits in which we have confidence, we really do not have a rational basis for determining *economic* viability of any level of environmental quality. We certainly do not want to incur costs for increments of environmental quality improvement if the incremental benefits are less than those costs.

A major environmental policy issue is: How much improvement in the quality of the environment does society want? The corollary to this is, how much will society pay to improve the quality of the environment? What will they trade off (and how much of it) to get environmental improvement? I believe this issue has to be resolved before any comprehensive environmental policy can be developed.

Neither the total costs nor the total benefits are developed to the point where they can be used to select levels of pollution abatement or environmental quality with confidence that the test of incremental benefits equalling incremental costs has been met.

In commenting on the policy dilemma of providing economic incentives within the existing regulatory framework, Greenfield points out that the regulatory process fails to

> . . . use financial incentives and the mechanisms of the market place to encourage industry to abate rather than to pollute because it will remain more profitable to pollute than to be innovative in applying expensive abatement technologies. How do we go about developing public policy to change this so that the same economic forces which drive the economy successfully in other areas will work to enhance environmental quality?

To approach an answer to this question, we must understand why market forces have hitherto made it more profitable to pollute than to abate. Simply put, air and water until recently have been for all practical purposes, treated as free goods. In like manner, we have considered land and many natural resources sufficiently plentiful or of such little market value that we use land for dumps for solid wastes, toxic substances, etc., we abandon strip mines without restoration, and we encourage the depletion of natural resources, such as oil. So long as this philosophy prevails, the market costs of technological enterprise will not include the social costs of the human and ecological damages of pollution. So long as such costs can be "externalized" by shifting them to others, the polluter finds it more profitable to pollute rather than abate.

Policies to include such costs as part of the cost of production will increase the prices paid by consumers. This will "internalize" the costs, and the market pricing mechanism will no longer be distorted by allowing consumers to shift the pollution externalities to other sectors of society who do not benefit.

At the present time, sulfur and auto emission taxes to complement the Clean Air Act, and effluent fees and sewerage charges mandated under the new water quality act, are being considered to provide market incentives for abatement rather than pollution. The simple economic logic of such approaches is that if taxes or charges have to be paid on pollutants, and if they are sufficiently high to make it more costly to continue to pollute than to abate, then there will be a profit incentive to develop and apply abatement technologies.

In addition to the need to develop the information required to determine the appropriate structure of such tax (as opposed to subsidy) incentives, there are two general problems which create a dilemma for EPA in developing plans to implement such a policy. One stems from the real fact of life that producers and consumers now avoiding paying the costs of pollution will not willingly accept the higher costs of production/price of consumption. Thus, pressure against such incentive taxes may be expected from present groups not now internalizing such pollution costs.

A second issue arises from the fact that EPA must carry out the mandate to abate pollution within a regulatory framework.

The mandate requires research, development and demonstration capability to carry out this mission. In a sense this is counter-productive to the longer-range objective of providing incentives for technologically-based enterprise to assume this responsibility and incorporate the total cost of abatement into costs reflected in market prices.

## Other Elements of Environmental Policy

The review of major government activities in the environment presented above shows that the thrust of the government programs has been largely regulatory. Other approaches to environmental management which have not yet started to any extent but which may become increasingly important methods for implementing environmental policy include development of economic incentives and application of technology assessment.

Certain economic incentives have been proposed as supplements to regulation or as additional means of managing the environment. Tax write-offs and federal assistance to industry have been suggested to foster pollution control. Charges or taxes on pollutive effluents or emissions, especially backed by standards and regulation, could provide an incentive to industry to control pollution. Examples are the gasoline lead tax and proposed taxes on sulfur oxides emission.

In many instances the cost of controlling pollution will probably be passed on to the ultimate consumer. Therefore, the public can be expected to take a strong interest in such proposals, if adequately informed.

Technology assessment means determining the full impact of new technology, including secondary and tertiary effects before the technology is applied. This follows from the emerging viewpoint that the manufacturer or industry must show that his proposed activity will produce no harmful environmental effects before he procedes. The idea is not new, but its application to environmental management is new.

Such proposed environmental management techniques illustrate the need for a systems approach. Technology assessment, by definition requires a detailed understanding of all elements of the environment in order to accurately assess the impact of new technology. Incentives, to be effective, also require detailed knowledge of the environmental system and its economics.

## *Lessons Learned—An Opposing Viewpoint*

One of the environmental areas receiving wide attention is that of pesticides. Following Rachel Carson's dramatic plea in "Silent Spring" public concern led to greatly increased federal and state regulation of pesticides. The use of DDT was essentially eliminated. In the following discussion Donald Spencer, Consulting Ecologist for the National Agricultural Chemicals Association questions some of the earlier analyses and forecasts and points out some little-discussed potential positive effects of enlightened use of pesticides.

## Evidence of Declining Pesticide Residues

Most of the tests that have been designed to show the acute and chronic toxicity of pesticides in water use a solution of the pesticide. In long-term, low-level exposure, a solution of the pesticide is "dripped" into a mixing stream on a continuous basis, then into the test aquaria. For example, in one well-conducted study oysters were raised from juveniles to sexual maturity at a constant exposure of one part per billion of (ppb) DDT in flowing seawater. By the end of the 12th week of the test, the oysters had acquired a body residue of 74 parts per million (ppm), a factor of 75,000 greater than the quantity at any one time in the seawater. The residue in the oyster had not changed significantly at the end of the 24th week, and by the end of the 36th week of continuous exposure had dropped back to 60 ppm(1).

What was observed is a common phenomenon with DDT and related chlorinated hydrocarbons. When first exposed to the pesticide, residue levels in the body rise rather sharply, then level off or may subsequently decline to a somewhat lower plateau. This is a "steady state" in which input is balanced by degradation and excretion of the DDT. The height of the body residue level will vary with the degree of exposure. After 36 weeks of exposure to these very dilute solutions of DDT (which is the maximum solubility of DDT in pure water) the DDT use was terminated and the oysters exposed only to uncontaminated seawater. In the following 12 weeks, the DDT residues in the oysters declined from 60 ppm to 0.16 ppm.

The above study illustrates the oyster's capability to accumulate DDT residues some 75,000 times the environmental background levels—if the chemical is in solution. In December 1972, Dr. Philip A. Butler, who has been in charge of the *National Estuarian Monitoring Program* since its inception in 1965, reported on the results of pesticide analyses in 8,095 samples of oysters collected from 183 permanent estuarian sites in the United States, including Alaska. The maximum DDT residues detected (1.0 to 5.4 ppm) occurred in less than 0.5 percent of the samples. The percentage of samples containing negligible residues (0.01 ppm) during the last year (1971) as compared to earlier years increased 85 percent in 12 of the 15 States where estuarian monitoring took place. His concluding paragraph states, "The data demonstrate that the decline in DDT residues in molluscs has been nearly universal on the Atlantic, Gulf of Mexico, and Pacific Coasts, although beginning at different times at different places. In some areas DDT has disappeared from this filter-feeding level of the trophic web within 12 months of the termination of its local use. This suggests that barring further input, DDT will disappear biologically within one or two generations of sensitive estuarine fauna."(2).

Given the oyster's ability to accumulate 75 ppm of DDT from a background level of only 1.0 ppb, and a finding that the highest residue in natural populations was 5 ppm, we must conclude that most of the DDT was precipitated out in silt and organic matter before it reached the estuaries, or that the silt-complexed DDT is not as available for cycling in the food web as had been anticipated, or that it undergoes fairly rapid degradation in the brackish waters of the estuaries. Regardless of the explanation, residue levels are declining.

Before leaving the discussion of the declining residues of DDT and its metabolities, it might prove useful to indicate supporting data from other studies. Since 1964, the Food and Drug Administration has been recording the pesticide residues in ready-to-eat foods. Samples of every class of foodstuffs were collected from 30 markets in 28 different cities and prepared for the table. The diet used was that of a 16-year-old boy. In the period June 1969-April 1970, "the daily intake of total chlorinated organics dropped 22 percent from the previous reporting period (June 1968-April 1969)"(3).

One segment of the "*National Human Monitoring Program for Pesticides*" has now been published (4). This activity comes under the Pesticide Community Studies of EPA which, among other projects, has established and maintained in 14 States epidemiology studies by contractual arrangement with State health departments and/or local medical schools. The State of Utah, Department of Social Services, Division of Health, reports: "Mean values of total DDT in adipose tissue for the years in which these samples were obtained were 9.0 ppm in 1968, 7.2 ppm in 1969, and 5.3 ppm in 1970, indicating a decrease in storage levels" (5).

The English have also been following the residue levels in human fat in the United Kingdom since 1963. In a report covering the period 1969-1971, published in the British Medical Journal, the following conclusions are drawn:

"It is again gratifying to record that the mean concentrations of the three main organochlorine pesticides found in human fat (in the United Kingdom)—namely BHC, dieldrin, and DDT—have continued to decrease over recent years . . . . If the results from the latest study are compared with those obtained in 1965-67, the decrease in the dieldrin content, based on the geometric means for all samples, is equivalent to about 30 percent of the earlier value . . . while the decrease for the total DDT is slightly over 20 percent of the earlier value." (6).

It is difficult to reconcile the above monitoring results with the following statement from a Report for The Club of Rome's project on the predicament of mankind, entitled "The Limits of Growth" (7): "The graph (Figure 22, DDT Flows in the Environment) shows what would happen if in 1970 the world

DDT application rate began to decrease gradually until it reached zero in the year 2000. Because of the inherent delays in the system, the level of DDT in fish continues to rise for more than 10 years after DDT use starts declining, and the level in fish does not come back down to the 1970 level until the year 1995—more than two decades after the decision is made to reduce DDT application." I believe that the error made here was that in their computer programming they equated DDT with persistent chemicals known to have half-lives running into tens of thousands of years. For example, at another point in the Report the following statement appears: "We include only one class of pollutants—the long-lived, globally-distributed family of pollutants, such as lead, mercury, asbestos, and stable pesticides and radioisotopes—whose dynamic behavior in the ecosystem we are beginning to understand."

In no way can DDT and related chlorinated hydrocarbon insecticides be classed with lead, mercury, asbestos, and certain stable radioisotopes in terms of persistence in the environment. DDT can be degraded by light, high temperatures, chemical action, and a goodly number of fungi and bacteria. I know of no species of fish, bird or mammal that cannot at least partially metabolize and excrete DDT, although at greatly differing rates. The compound may last as short an interval as two hours in activated sewage sludge. On the other hand, a soil can be so overloaded with DDT that it kills the very micro-organisms on which degradation may depend. Certainly when incorporated in soil below the zone occupied by living organisms, and in the absence of oxygen, it persists for long periods. But the fact remains that it is degradable and does not accumulate remorselessly in the living environment. Had we from the outset of this era of environmental concern been able to demonstrate that, by adjusting the input of DDT, unacceptable residues in non-target species could be reduced as rapidly as the current monitoring programs are indicating, our regulatory programs might have taken a different course.

## Specific Lessons Learned

It was generally assumed that the far-flung residues of DDT found in fish and wildlife were the result of progressive build-up of environmental levels from 25 years of continued use. Many statements appeared warning that to add another season's use, another pound, might push the residue level beyond a threshold where another species of wildlife might become endangered. None of the monitoring programs to date that have covered a span of years have shown any progressive build-up of environmental background residue levels of DDT. The perfection of gas chromatography for residue analysis, and the extension of residue monitoring beyond that of man and raw agricultural foods, did not take place until the middle 1960's.

We cannot document the general environmental background residue levels of DDT and its metabolities prior to 1965. However, I hold the conviction, based on more recent studies of rates of disappearance of DDT residues, that an environmental background "steady state" had been reached by the mid-1950's and was being sustained at that point by the annual input. Please note that we are still working with residue information for 1965-1970, at which time there were still fair amounts of DDT in the "user pipeline" in the United States. I look forward with much interest to the residue information for the period 1971-1973, during which time most of the remaining uses of DDT in the United States were phased out.

DDT does not represent the type of problems encountered by all pesticide chemicals—only a very small group of related chlorinated hydrocarbons. The remaining 99 percent show a wide range of chemical structure, differing one from the other in possible effects beyond their design purpose. But from our experience with DDT, there are several valuable lessons that have applicability to future regulatory programs governing all classes of chemical contaminants.

*First:* There is need for greater understanding of, and appreciation for the principle of dose-related effects!

*Second:* The design of tests to develop pre-registration, or pre-marketing safety information should take cognizance of the applicability of the data to actual field use. For example, if the limit of solubility of a given pesticide in water is 2 ppm, then an acute toxicity study, in which the aquatic animal is exposed to 20 ppm with the aid of auxiliary solvents, is merely an academic exercise—but it will mislead and alarm the public. The highly controversial study conducted at the Bionetics Research Laboratories on a technical sample of the herbicide 2,4,5-T not only focused attention on a manufacturing impurity in the herbicide, but introduced a "fudge factor" in the study by using dimethyl sulfoxide as a solvent (8).

Third: We have moved too rapidly in some cases when unanticipated adverse effects surfaced and discarded a tool before we had another to cope with the pest problem. A moratorium imposed on the use of a pesticide whose safety is not flawless should stipulate that the Administrator, after careful review of the risk/benefit equation based on an environmental impact study, could permit the use on a case-by-case basis.

Fourth: The regulation of pesticide chemicals presently falls under six pieces of Federal legislation (Table 1). Regulation of pesticide chemicals began as early as 1910. In 1947, the passage of the *Federal Insecticide, Fungicide, and Rodenticide Act* provided for registration of all pesticide products and set up an enforcement procedure based on labeling and control of interstate shipments. The requirements for registration specified that the manufacturer provide test data showing his product to be both effective

## Table 1. Federal Legislation Regulating Pesticides—1973

1) FEDERAL ENVIRONMENTAL PESTICIDE CONTROL ACT OF 1972. (Pub. Law 92-518)
Regulates manufacture and sale. Regulates the practice of formulator, distributor, and applicator. User can be penalized for incorrect use. Requires very comprehensive premarketing evaluation of product effectiveness, safety, and environmental impact. Authorizes research and monitoring programs on pesticides.

2) FEDERAL WATER POLLUTION CONTROL ACT: Amendments of 1972. (Pub. Law 92-500)
Regulates point discharges of effluents (including pesticides). Sets standards for individual chemical residues in water.

3) FEDERAL FOOD, DRUG, AND COSMETIC ACT: Miller pesticide residue amendment of 1954. (Pub. Law 83-518)
Authorized to set tolerances for pesticides in raw agricultural products and to monitor the food source and seize products that do not conform.

4) OCCUPATIONAL SAFETY AND HEALTH ACT OF 1972. (Pub. Law 91-596)
Authorized to set health and safety standards for personnel during manufacturing, formulating, or use of toxic agents. Claims authority to set re-entry time into areas treated with toxic substances.

5) POISON PREVENTION PACKAGING ACT. (Pub. Law 91-601)
CONSUMER PRODUCT SAFETY ACT. (Pub. Law 92-673)
Requires household products containing hazardous pesticides to be packaged with a safety closure that children five or under cannot open.

6) NATIONAL ENVIRONMENTAL POLICY ACT OF 1969. (Pub. Law 91-190)
Requires all agencies conducting pest control programs, whether on public lands or by cooperative agreement on private lands, to prepare environmental impact statements before initiating action.

and safe. This 1947 law was periodically updated and the pre-marketing requirements made more exacting. The new Federal legislation that amends and supplements the earlier Act are truly comprehensive and stringent.

The State legislation on pesticide regulation and associated environmental quality actions form a veritable maze of controls (Table 2). The attempt to legislate "safety" has now been carried to such a length as to justify the question, have we over-reacted?

**Are Pesticides Over-Controlled?**

The evaluation of the safety and effectiveness of a pesticide chemical before it can be marketed has become so detailed and time-consuming that if a promising new pesticide emerged from the preliminary screening trials this morning, it would be a minimum of five years before it could be made available for public sale. The research needed to satisfy Federal registration will take that long. Despite this intense pre-market safety check, not enough questions can be answered to preclude the development under subsequent use of some undesirable effects. A very necessary adjunct to the pre-market evaluation of pesticides are the national monitoring programs. Started as a voluntary, interdepartmental Federal program in 1964, it is now a required program under the *Federal Environmental Pesticide Control Act of 1972*, for which the Administrator of the Environmental Protection Agency is responsible (Section 20(b) and (c)). This monitoring activity supplements, in the general environment, the pesticide residue monitoring programs in raw agricultural food products that have been conducted by the Food and Drug Administration since 1954, and by the U.S. Public Health Service for pesticide residues in man since 1951. Initially the broadened program in 1964 put too much reliance in the yet-developing gas chromatography, thus quantification of a given residue was often inaccurate. Still another shortcoming that plagues the monitoring program is the loss of time—2 years—between the collection of samples and the publishing of results. If the monitoring programs are to pinpoint trouble spots, and alert us to practices that result in environmental accumulation so that the problem can be met before a crisis arises, then prompt release of information is imperative.

The task of the residue analyst is an exceedingly difficult one, for he must recover not only the parent compound but also its metabolites from a wide range of biological materials loaded with interfering substances. He often is forced to work in the parts-per-billion or in the parts-per-trillion range. But what is most disconcerting is to study an excellent piece of residue analysis, then find that such inadequate notes have been taken when the sample was collected as to obviate any application of the residue information. Despite its present shortcomings, environmental monitoring is

### Table 2. State Legislation Augmenting Federal Regulation of Preticides December 1971

All 50 States and Puerto Rico have a

PESTICIDE REGISTRATION LAW

36 States have established a category of

RESTRICTED USE PESTICIDES

21 States have legislation

REGULATING HERBICIDE USE

20 States have legislation

LICENSING PESTICIDE DEALERS

35 States have legislation

REGULATING CUSTOM APPLICATORS OF PESTICIDES

36 States have legislation

LICENSING STRUCTURAL PEST CONTROL OPERATORS

NOTE: During 1972 the States enacted into law 41 additional pieces of legislation bearing on pesticide regulation. The Federal requirement for licensing of custom applicators will, of course, be nationwide within the next four years. Likewise, the Federal list of restricted-use pesticides will also apply nationwide. At the State level the use-restrictions can only be more stringent.

still one of our most valuable tools for achieving environmental quality. There is no completely safe pesticide, any more than there is a completely safe lawnmower or a completely safe electrical circuit just safe ways of using them. A given pesticide of high toxicity may be used effectively and with no significant adverse side effects by limiting the amounts used, by placement that avoids exposure of beneficial species, by timing that accomplishes the same end and by formula additives that warn or repel.

## Benefits From Pesticides and Chemicals

Pest control chemicals were intended from the outset to make this earth a better place in which to live. They are designed to assist in improving environmental quality—not to degrade it. It is not difficult to find where these chemical tools have been incorrectly employed by intent or accident. There will always be need for improvement. Nevertheless, the end result is that today in the United States we have better health and live longer than the people who preceded us. In the early 1900's, the corner grocery store carried about 100 food items and no fresh fruit or vegetables out of season. Now the modern supermarket carries about 6,000 food items in better variety, quality, and availability throughout the year. There are more fish to be caught in our freshwater streams and lakes, and more wildlife than there was 40 years ago when the new class of pesticides began to be used. I am not saying that because of pesticides there is more wildlife today, but neither am I discounting the role it plays in our total wildlife management programs (Table 3).

We have more leisure time since chemical tools have replaced much drudgery and wearisome toil. We have more recreational opportunities in the great outdoors than people anywhere else around the globe, partly because our advanced thechnology—which includes chemical tools—has made it possible for us to provide ourselves with the basic requirements for existence on fewer acres. For example, the technological package that permits us to produce more food on fewer acres (by soil conservation, improved cropping procedures and irrigation, new plant varieties, new breeds of livestock, sophisticated machinery, fertilizers and pesticides) has released approximately 290 million acres that we can now use for other purposes, such as open space, recreational areas, and wildlife refuges. Forests and timbered tracts occupy about a third of our total land area in the United States. Although trees are a renewable resource, which should be promptly harvested at some optimum stage in their growth and the area immediately restocked, nevertheless we would like to be able to retain a significant portion of this resource to frame our homes, shade our parks, furnish recreation and wilderness areas, and even become decadent and hollow, thus providing bird and wildlife nesting sites. But lumber and pulp

## Table 3. Enhancement of Wildlife Population by Pesticide Use

MORE FISH IN FRESH WATERS for 25 million anglers a year to harvest. Fish hatchery support impossible without chemical tools.

RECOVERY OF SPORT FISHING IN THE GREAT LAKES credited to a pesticide. Re-build fish stocks possible after control of Lamprey eel.

ANADROMOUS FISHERIES IN THE PACIFIC NORTHWEST ON THE COMBACK TRAIL. Hatchery and rearing pond operations require chemical tools

AQUICULTURE OF FISH AND SHELLFISH requires algal and parasite control. Mountain trout and catfish farming--also new mariculture operations.

MAN'S INCREASED FOOD PRODUCTION IS SHARED BY WILDLIFE. An important percentage of the annual food requirement of many species.

RECYCLING BROWSE THAT HAS ESCAPED BY HEIGHT GROWTH is accomplished by herbicides without cultivation or replanting.

ESTABLISHING AND MAINTAINING OPENINGS, BROWSEWAYS, AND CORRIDORS by selective herbicide methods benefits game and non-game animals.

PREVENTION OF HABITAT DESTRUCTION BY INSECTS AND DISEASE, such as large scale forest defoliation and destruction, serious denuding of rangelands by grasshoppers, etc.

MARSH AND WETLANDS CAN BE TOLERATED AND SAVED AS WILDLIFE HABITAT because of our capability to control insect vectors of disease for man, such as the mosquito, blackflies, etc.

CONTROL OF LIVESTOCK DISEASES MATERIALLY BENEFIT BIG GAME. Deer and exotic big game in Texas increased rapidly following suppression of the Texas cattle fever tick and the screwworm.

CONTROL OF POULTRY DISEASES AND PARASITES ALSO PROTECTS UPLAND GAME BIRDS. A part of the success of the re-introduction of the wild turkey can be credited to lessened exposure to poultry diseases.

MARSH DWELLERS STAND TO GAIN HEALTHWISE FROM MAN'S INSECT CONTROL PROGRAMS. For example, Canadian geese suffer mortality from a form of malaria, transmitted by a marsh mosquito.

WILDLIFE CAN BE A RESERVOIR OF DISEASE TRANSMITTED ANIMAL TO MAN. Because we have pesticides to control the insect vectors, we are privileged to keep these potential carriers of diseases around us, such as song birds/encephalitis.

will be in short supply by 1980. So our set-asides for the above purposes will depend on the success of the technological advances recently announced by the forest industry—that through the development of fast-growing, superior class trees and improved silvacultural practices, they can triple the production of fiber per acre of commercial forest.

Similarly, the technological package that enables us to ship, store, process, package and serve foods *after they are harvested*, with minimal loss or lowering of quality, makes it unnecessary to employ still more acres to make up for losses that in some under-developed countries may equal a third of their production. Chemicals to control fungi and bacteria which cause spoilage and decay of foods are required to be registered as pesticides along with the better known chemicals that control insect pests and rodents. Pesticides do a yeoman job as sanitizing agents in flour mill, bakery, retail store, restaurant, and in our homes. How would we run a hospital without them?

Technology indirectly releases another huge block of land—perhaps another 200 million acres—and helps to conserve non-renewable resources for the furture by prolonging the utility of manufactured goods. In the home many items such as rugs, draperies, overstuffed furniture, mattresses, and clothing received some chemical assistance at the manufacturing level against factors of deterioration and destruction. The housewife supplements this with spot treatments against fabric-eating pests like carpet beetles, silverfish, moths, roaches, and even an occasional mouse or rat. She fights mildew and mold. She launders these fabrics with gentle soaps and detergents in a modern washing machine. This is a far cry from the harsh soaps, and the repeated flailing of the wet garment on a rock at the river's edge (as is common at the village level in India). All this means less replacement, fewer acres needed to grow cotton, less pasture for sheep, and less basic chemicals from wood and oil.

Man's technological ability is forever creating new problems but at the same time it has provided him many choices and opportunities for developing and maintaining a quality environment in which to live. As stated by Dr. Rene J. Dubos in a lecture given before the American Association for the Advancement of Science, "In my opinion, the human use of natural resources and of technology is compatible with ecological health, and can indeed bring out potentialities of the earth which remain unexpressed in the state of wilderness" (9).

## Conclusion

Spencer's discussion is an excellent illustration of the common problems of environmental management. Early perceptions and analyses of potential persistence of pesticides and entry into the food chain led to intensive regulation. Now, although data are not complete and continual monitoring is required, Spencer sees evidence that perhaps the pesticides were not as persistent as originally thought.

He relates advantages of controlled pesticide use emphasizing that millions of acres may be released for recreational and other uses through enlightened management.

He also shows that pesticides are now regulated by at least six pieces of legislation administered by several different agencies.

In this example, then, we see the omnipresent need for research and information, unifying concepts and systems analysis.

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# 2

# IMPLICATIONS OF ZERO POPULATION GROWTH

## *Introduction*

Our population is growing and public perception of environmental quality and other social problems is focused on our population growth. Public officials at all levels of government have expressed concern and indicated a need for action.

Recently the birth rate in the United States dropped to about 2.1 children per female, less than the replacement rate. We have, at least at this instant of time, reached the magical Zero Population Growth (ZPG) rate. Even if the birth rate remains at or below this level for many years, we will not achieve a Zero Population Growth in absolute numbers. This is so because the relative number of young women in the population mix is large. As each of these women bears an average of about two children, the population will grow. We are also faced with the problem of high concentrations of population in urban areas. Therefore it is likely we will experience a growth in population, more intense in urban areas, and must deal with an accompanying economic growth and possible environmental degradation while we also seek to discover new approaches for improving the quality of life.

The discussions of ZPG, its effect on the environment and implications for policy are taken from several invited papers. Current population forecasts are reviewed. Graham Molitor discusses reasons for the decline in fertility rate. Fred Singer concludes that the fertility rate will remain somewhere near the present low and presents social, cultural and economic reasons for his conclusion. Christakis and Molitor [illegible] the trend toward urbanization and review its social and economic consequences.

The effects of population growth on the environment under conditions of ZPG rate are outlined by Christakis using a simple model to illustrate the relationship between population, population density and pollution levels.

Singer discusses economic and welfare implications of ZPG, outlining a hoped-for improvement in quality of life which might be possible if the birth rate remains low.

After reviewing the determinants of resource and environmental pressures, Ridker presents the results of an analysis of the effect of population growth and current policies on the quality of life, life style, and adequacy of resources and quality of the environment.

Ridker concludes that direct methods of achieving an improved quality of life and environment are superior to indirect methods and less specifically-stated goals such as Zero Economic Growth and Zero Population Growth.

## *The Pressure of Population*

The world's population is currently increasing at about two percent annually, causing a doubling in population every 35 years. It took two million years for the earth's human population to reach the one billion mark. This milestone was achieved in the year 1830. By 1930, merely a century later, the world population had become two billion. If the current annual rate of growth of world population were to continue at this pace, the earth would be home for 12 billion human beings by the year 2030. Just seventy years after that, in the year 2100, there would be 50 billion human inhabitants of this small planet!

Von Foerster and his colleagues calculated an equation describing current worldwide trends of population growth (1). The Von Foerster data is based on the best estimates of world population over the past 2,000 years. In simple form, the equation reveals that each successive doubling of world population has required only half the time as the prior doubling.

This growth process is characteristic only of man as a self-conscious being. All the advances accruing over the past forty millenia with regard to individual capacity, understanding, elaboration of social roles, technology, and human well-being are mirrored in this increase in population. Increasing population led to successive environmental crises which served as stimuli for their creative resolution through the generation of concepts that permitted linking more people into larger communication networks and the more effective fabrication of natural resources to meet new demands.

Thus we are led to the conclusion that the overall impact of increase in numbers has been beneficial. But we are further led to ask the question: "How much longer can this trend persist?"

For man to survive and to evolve further there must be a sudden shift in certain aspects of the growth process. Calhoun states forcefully that: "The guiding of man and nature through this phase shift stands as the basic issue in the presently emerging environmental crisis" (2). Ameliorating pollution and stabilizing the biosphere, though they are essential actions, are insufficient to assure resolution of the current evolutionary-environmental crisis. Graham Molitor comments as follows:

In his Population Message of July 18, 1969, President Nixon stated: "One of the most serious challenges to human destiny in the last third of this century will be the growth of the population."

Kenneth Boulding adds: "One of the most difficult problems facing mankind in the present historical era is the control of its own population!" (3). Boulding refers to "population *equilibrium*" as a critical unsolved problem.

The President also attributed the wrenching dislocations in coping with problems in the last few decades to the geometrical growth of population during the last half century: "I believe that many of our present social problems may be related to the fact that we have had only fifty years in which to accommodate the second hundred million Americans." (4).

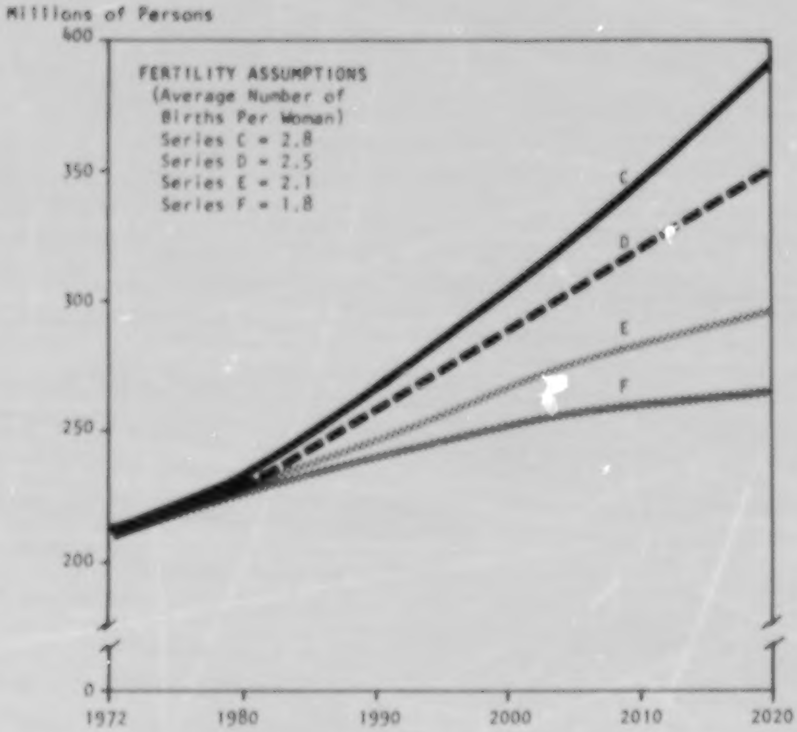
These remarks underscore the importance of current population pressures. In responding to the importance of the issues posed by population growth, a Commission on Population Growth and the American Future was established by Act of Congress and signed into law on March 16, 1970.

The studies published by this Presidential Commission articulate, quantify, and realistically describe the seriousness and pervasiveness of the world population problem. The ultimate conclusion reached is that population growth (and perhaps economic growth) must halt because of finite resources—the only questions are "when, where, and how." (5).

## U.S. Population Forecasts

The latest population forecasts for the United States, as estimated by the Department of Commerce, are shown in Figure 1 and Table 1 (6). Forecasts are made for four assumed fertility rates as shown in the Figure. The fertility rates have been revised downward since previous forecasts due to sharp declines in fertility since 1970 and to the sharp decline in the birth expectations of young wives during the past five years. Assumptions for mortality rates have been revised slightly and net immigration is assumed to be 400,000 per year.

The assumption of lower fertility rate appears to be justified by recent experience. For the first nine months of 1972 the rate fell to 2.03. This rate is below the replacement rate—the rate at which children must be born for the population to maintain itself. This does not mean, however, that the population can be expected to level off or be reduced in the near term. The relative number of young women in the population mix is high, therefore the population will continue to grow for some time. For example, at a constant birth rate of 2.1, the population would grow from the present 210 million to 320 million in 70 years, then level off. At a rate of 1.8, the population would grow to 260 million in 50 years, then level off. Thus, although the United States is experiencing a birth rate equal to or less than a Zero Population Growth rate at this instant in time, we will experience a population growth for some time to come.



Source: U.S. Department of Commerce Series P-25, No. 493, December 1972

Figure 1. Projections of Total Population: 1972 to 2020

Table 1. Summary of Projections of Total Population: 1960 to 2020 (Population in thousands. Total population including Armed Forces abroad)

| Year (July 1) | Series C | Series D | Series E | Series F |
|---|---|---|---|---|
| Estimates | | | | |
| 1960............ | 180,671 | | | |
| 1965............ | 194,303 | | | |
| 1970............ | 204,879 | | | |
| 1972............ | 208,837 | | | |
| Projections | | | | |
| 1975............ | 215,872 | 215,324 | 213,925 | 213,378 |
| 1980............ | 230,955 | 228,676 | 224,132 | 221,848 |
| 1985............ | 248,711 | 243,935 | 235,701 | 230,913 |
| 1990............ | 266,238 | 258,692 | 246,639 | 239,084 |
| 1995............ | 282,766 | 272,211 | 256,015 | 245,591 |
| 2000............ | 300,406 | 285,969 | 264,430 | 250,686 |
| 2005............ | 321,025 | 301,397 | 273,053 | 255,209 |
| 2010............ | 344,094 | 318,156 | 281,968 | 259,332 |
| 2015............ | 367,977 | 335,028 | 290,432 | 262,631 |
| 2020............ | 392,030 | 351,368 | 297,746 | 264,564 |

## *Determinants of Population Growth*

The basic determinants of population growth are three: birth rate, death rate and net migration. Graham Molitor comments as follows:

Of these three factors, by far the least stable is birth rate. During the past half-century the United States, as well as other countries, has achieved a fairly constant death rate, based on decreasing infant mortality rates and relative stability of life-spans. The U.S. Census Bureau estimates net migration for the U.S. at approximately 400,000 per year.

The birth rate of the United States and other industrialized countries, then, emerges as the single most important variable in forecasting future growth, as well as in selecting means to control future population.

### The U.S. Birthrate

The factor determining a nation's birth rate is the fertility rate found within its population. The fertility rate in the U.S. has been steadily declining as shown in Figure 2. Graham Molitor lists reasons for this decline, as follows.

—more young women staying single;
—more women starting families later;
—more working wives ("when women are able to work, birth rates decline");
—more women careerists (in 1971 women accounted for some 43 percent of the labor force; in 1960 the figure was 34 percent);
—increased use and effectiveness of contraception;

Expanding on these reasons Molitor states that a wide variety of additional natural and artificial constrictions on family size provides a fuller understanding of this downward shift:

1. *Child bearing capacity:* Women can bear children for some 30 years (ages 15 through 45) and may give birth to a maximum of approximately 20 children (7). Few women, however, produce maximum broods. Cultural and economic inhibitions and the tendency to marry later deter maximum sized families. Modern "fertility drugs" and the side-effect of multiple births could raise this level somewhat. In other

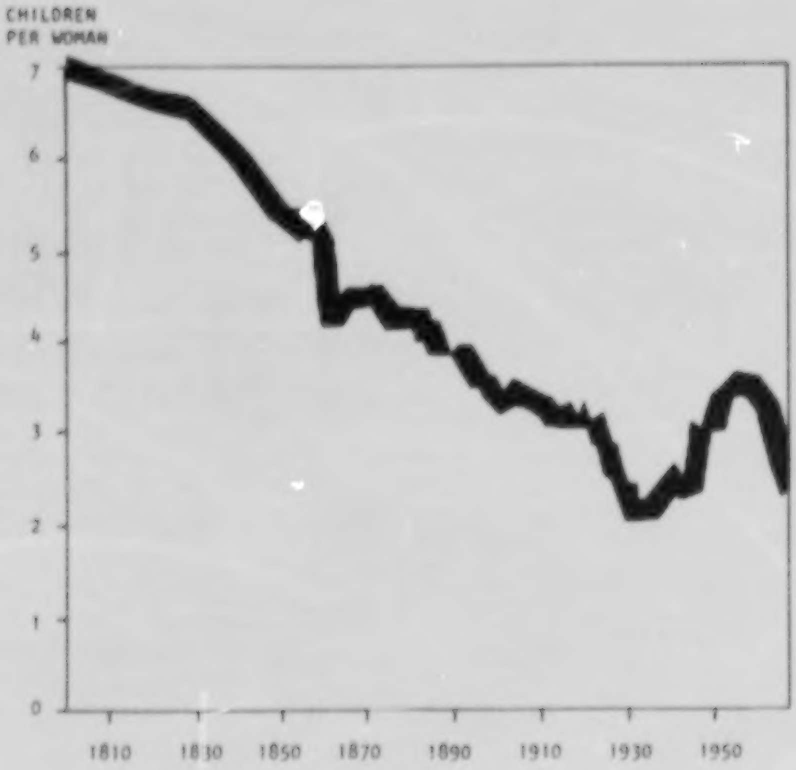


Figure 2. Historical Trend in U.S. Fertility Rate (SOURCE: "Population and the American Future: The Report of the Commission on Population Growth and the American Future," March 1970.)

words, social variables, rather than biological factors, tend to constrict birth rates.

Techniques for bypassing one mate or the other must be considered:

- —children conceived by artificial insemination (anonymous or selected semen donors);
- —surrogate (host) mothers (ovum and sperm from anonymous or selected donors).

Also to be factored are new life science developments that may completely bypass normal reproduction:

- —human clone (humans grown from "cuttings");
- —extra-uterine developments ("ectogenesis," human "hatcheries");
- —artificial wombs;
- —creation of artificial life forms.

2. *Females in child-bearing age bracket.* Women in the prime child-bearing age group—females age 20-34—bear special attention, since 4 of each 5 babies born come from this group. Some 25 million women will be in this age group in 1975; the number will grow to some 30 million women by 1985. The Commission on Population views prime childbearing ages at 20-29 and predicts that this group will grow 5 1/2 million by 1985. Such increases would exert even stronger upward pressure on population growth (8). This projected 20 percent growth pattern will have an upward pressure on population growth.
3. *Number of marrieds.* The number of married couples is another factor bearing on population trends. The size of this group "is expected to rise from 42.3 million in 1965 to 51 million in 1975 to 60 million in 1985" (9). This increase of nearly 50 percent will add to potentials for population growth. Currently there are unusually large numbers of young men and women, a result of the post war "baby boom." Naturally the number of marriages and household formations has been increasing. Despite these facts, the birth rate has been declining and has actually reached the lowest point in our history.
4. *Sexual permissiveness.* The "sexual revolution" and growing permissiveness in sexual relations and cohabitation between consenting adults could significantly affect population growth. Women's new sexual permissiveness made possible by more effective and simpler contraceptives, sterilization, abortion, and other new technologies encourages sex for pleasure rather than propagation. Widespread availability of inexpensive and effective contraceptives should netralize the overall impact of sexual permissiveness on population growth.

More permissive attitudes towards homosexuality and lesbianism also may have some incremental effect on subduing population growth.

5. *Age at first marriage.* Putting marriage off to later life provides fewer years for married couples to conceive children and the potential for population growth is reduced. The higher proportion of children going on to college and military service obligations contribute to marriage postponement. Between 1956 and 1967 the median age for marriage rose from 20.1 to 20.8 years for females, and 22.5 to 23.1 years for males (10). More current Census figures indicate continuation of the trend toward postponed marriage—between 1960 and 1972, the median age at first marriage for women rose from 20.3 to 20.9 years, and the proportion of single (never married) among women 20 to 24 years old rose from 28 percent to 36 percent (11).
6. *Childless couples.* The number of childless couples has been declining. In 1940 23 percent of married women age 30-34 were childless; by 1960 the proportion dropped to 10 percent and then to 6 percent in 1968 (12). This has an obvious impact on population increase.
7. *Unwanted births.* Portending further decrease in the "replacement rate" is the fact some 20 percent of current births are "unwanted." The 1965 National Fertility Study speculated that "elimination of unwanted births would result in fertility levels ultimately commensurate with near-zero growth" (13). Given increased acceptance and availability of contraceptives and other "emancipating" techniques, it is highly likely that the fertility rate will decline still further.
    - 7a. *Unplanned births.* The Population Commission not only estimated up to one-fifth of all births were unwanted but that fully 44 percent were unplanned. If contraceptive technology applies to anything approaching this extent, the results on population growth will be most significant.
    - 7b. *Illegitimate births.* Growing in seriousness and importance is illegitimacy. In 1967 some 4.5 million children under 18 years were illegitimate. A study in the District of Columbia disclosed in 1970 that over 40 percent of all births were illegitimate, and projected the figure would reach 50 percent by 1973. Rates of illegitmacy among young women ages 15-19 increased 2-3 times between 1940 and 1968. Legalized abortion, effective sex education and contraceptive technologies doubtless would substantially reduce these demographics.

7c. *Birth expectations.* Wives in the 18-24 year bracket expect to have fewer births. The average dropped from 2.9 in 1967, to 2.4 in 1971, to 2.3 in 1972 (14). This decline is a continuation of a downturn in birth expectations of young wives. The changed attitude toward smaller families has an important bearing on the population slowdown.

8. *Smaller family size.* Family size has been steadily downtrending throughout the course of history. During the period of agrarian development, family size was much larger. At that time high infant mortality rates encouraged additional births, as did the need for manual labor to perform labor-intensive work in the fields. The 5 member family was not uncommon. At the time of the Revolutionary War, the 8-child family was common; in 1850 family size dropped to 6, then to 4 by 1900. Children born to couples in the 1930's averaged 3.3. In 1968 American families averaged 2.7 children. Today in post-industrial America we are down to the 2 child family. These trends have obvious effects on population decline.

9. *Abortion.* Legalizing abortion and widespread social acceptance and legal recognition thereof will decrease the number of likely births. Continuing to grow is the notion a woman should have the right of control over her body. Free abortion in Hungary, reportedly, contributed to the negative zero population growth in that country. Since 1968 the estimated number of recorded abortions has increased impressively (15).

| *Year* | *Number of Abortions* |
|---|---|
| 1968 | 18,000 |
| 1970 | 200,000 |
| 1971 | 400,000 |

The Commission on Population estimates in 1971 between 200,000 and 1,200,000 abortions were performed in the U.S. Some commentators view "therapeutic abortions" as an increase in the freedom of the mother (16). True. But, moral questions surrounding freedoms of the person conceived must also be considered.

10. *Divorce.* Marriages that stay together have an important bearing on population increases. In the first 9 months of 1972, the divorce rate stood at 4.0 per 1,000 Americans, close to the highest rate which ever occurred in the U.S.—4.3 persons per 1,000 (17). A related question concerns remarriage after divorce. Remarriages are far more prevalent among males than females.

11. *New lower Census projections.* Lower birth rate trends have been officially recognized by Census action in dropping Series B projections (assumed fertility rate of 3.1) and addition of the new Series F tract. Hard times like the Great Depression or involvement in World War II, which depressed birth rates to all-time historical lows, are understandable. What is truly extraordinary about the present all-time historical lows for birth rate is that it is occuring during a period of unprecedented prosperity. Many factors, especially those enumerated above, should be watched closely to track this trend. Should trends continue in their present direction, the U.S. will have entered a population stabilization or even negative population growth rate.

### The United States Death Rate

In terms of historical life expectancy, those of us living today are a privileged group of individuals. Before the birth of Christ, life expectancy was a mere 18 years. In the United States in 1970 life expectancy has been extended to 70 years. In less than 2,000 years man has quadrupled his life expectancy. The following is taken from Graham Molitor's paper.

The following tabulation indicates life expectancy increases in recent history:

| *Year* | *Life Expectancy* |
|---|---|
| B.C. | 18 years |
| A.D. | 22 |
| 1200 | 33 |
| 1600 | 33.5 |
| 1800 | 35 |
| 1850 | 40.9 |
| 1900 | 49.2 |
| 1946 | 66.7 |
| 1960 | 70.0 |

It is contemplated that average life expectancy will continue to climb, though at a slower rate. By the end of the century it could climb 1 1/2 years. Major breakthroughs in medical sciences could substantially increase this estimate. The prospect of people living longer has an obvious direct bearing on further population increases.

### Geriatrics

Because of the increased number of older persons, due partly to greater life expectancy, public policy is likely to focus increasingly on degenerative diseases manifested in later life. Life expectancy increases will come about due in part to development of major medical advances.

A wide range of exotic bio-engineering possibilities for extending longetivity, rejuvenating or even postponing aging follow:

—Discovery of a cure for cancer, heart disease and other major diseases;
—Better understanding and control of possible health hazards, such as; smoking, heart disease, air pollution, traffic fatalities;
—Improving medical systems including (computer monitoring of patients; computer assisted hospital care; closed circuit TV surveillance of patients);
—Development of immunizing agents protecting against bacterial and viral diseases;
—Widespread use, low cost availability of artificial organs;
—Easily available electromechanical implants;
—Renewal of organs by chemical, hormonal balance;
—Growing new organs to replace old ones, then storing or "booking" them until needed;
—Artificial hearts (implanted machines which will not be rejected);
—Postponing aging;
—Human hybernation;
—Suspended animation.

Political problems posed by such exotic developments are substantial. How to control rackets in transplantable organs; how to determine the point at which a host full of implants or external assists, or artificial organs ceases as a legal entity and becomes a new person; how to determine when a person is legally dead, how to determine inheritance rights, continuity of marital contract, responsiblity for legal contractual arrangements; how to allocate medical equipment when it is scarce and so expensive as to be unavailable to all but the rich; how to decide when to unplug persons from life-sustaining machines if the decision means certain death; how to view euthanasia.

Potential advances in medical science are mindboggling. Man stands close to the threshhold of breakthroughs which will have a major impact upon increasing life expectancy. Breakthroughs of the kinds enumerated will have a profound effect upon population pressures in the future.

### Infant Mortality

In recent years, the U.S. has ranked 16th in infant mortality. This is not an enviable position for the "most advanced" nation in the world. Once such quantifiable data is adduced and room for improvement becomes obvious, these facts become a force for change in their own right. We can expect increased efforts by the Federal government to reduce infant mortality.

### Life Expectancy Factors

Measuring *all* the factors which bear on life expectancy is an extremely difficult undertaking.

To underscore the complexity and subtlety of the kinds of data which are necessary to get a "total view" of such parameters, consider the partial listing of factors which might give a more sophisticated and holistic view of the national health and provide insights on the calculus of computing life expectancy: heart disease incidence; protein consumption; fat and sucrose consumption; caloric consumption; cancer incidence; poisonings; levels of radiological hazards; environmental hazards (toxic levels of gases, etc); decibel levels; infant mortality; preventive health rates; violent crimes; mental health average exercise; dental health; number of eye glasses and related eye disorders; consumption of selective drugs.

Such a list could go on and on. It is only partially elucidated to indicate the very complexity fully describing the nature of any particular facet of qualitative measurement. We already have volumes of such data. We need merely to collect it, aggregate it, interpret it, and develop a through-going and searching assessment of our current position based upon this quantifiable data.

### Net Immigration

Net immigration into the United States is expected to continue at present levels of about 400,000 per year, according to the Census Bureau and immigration officials. The demographic impact of immigrants is important because a high percentage of immigrants are in child-bearing prime and may be more likely to have larger families. From 1960-65, net civilian immigration averaged 364,000 yearly—twice the average of the 1940-9 era. Around 1900, immigrants per 1000 population stood at eight; around 1970 the rate had sunk to two immigrants per 1000 population—a fourfold reduction. Immigration is likely to be stabilized for the forseeable future—Congressional action to *enhance* immigration is less likely than action to *restrict* immigration.

## *Will the U.S. Maintain a ZPG Birth Rate?*

Singer believes that the present low fertility rate is not a temporary phenomenon but is a permanent change in the family pattern of our population. The sociological, economic and technical reasons, given by Singer are discussed below.

First of all, there is the increasing level of education which, in addition to allowing more effective contraception, also opens up to women other opportunities and other career goals rather than that of a housewife and mother.

Coupled with this is the greater affluence of the average American. During 1972 the median family income exceeded $10,000 per year, compared to $3300 in 1950. Even taking inflation into account, real income has more than doubled in a little more than 20 years. The proportion of families considered poor by the criteria that the U.S. government uses has decreased sharply, from 18 percent in 1959 to 10 percent in 1968, and may be expected to decrease further.

Not only has family income increased, but so has the income of women. To a large extent the changes have been legal and political as well as cultural and social. Rights legislation, the Equal Employment Opportunities Commission, and increasing acceptance of women into higher paying positions have had two effects. They have increased the income of women, but also opened up new prospects and increased expectations. Since large families and professional careers are not easily compatible, it is very likely that the incentive for larger families will be reduced.

A further change which appears irreversible has been the increased urbanization of the American population. In a rural environment the incremental costs of children are fairly small since they require little additional housing, and purchased food. In an urban environment, housing and maintenance can become quite costly. In a rural environment children provide a labor force—or at least did in past years in the United States, and still do in many countries. In the city, children do not have economically useful functions and usually need to be totally supported.

Increased social programs, such as social security and medicare for the aged, have removed to some extent the insecurity which many people feel concerning their maintenance in old age. In turn, this diminishes the need for children and other relatives who in the past have provided support for their parents.

A lower infant mortality may also be connected with a lower fertility. Having reasonable assurance that children will survive to adulthood, couples place less emphasis on a large family.

Altogether there has been a decline in pronatalist sentiments and policies. Whereas at one time large families were the source of general societal approval, this is no longer so. Families with six or more children are looked on as somewhat odd, and those with more than 10 or 12 are regarded with social disapproval. Unfortunately these social views have not as yet translated themselves into governmental policies. For example, we still have a pronatalist tax policy, although it is only mildly so. More serious, perhaps, is the fact that the costs of raising children are borne more and more by society as a whole, rather than being incident on the parents who derive pleasure from the child but few of the disbenefits.

We need to recognize, of course, that fertility may be determined to a large extent by fashions and fads.

One wonders to what extend our current environmental and ecological concerns are responsible for a lower fertility and to what extent the existence of ZPG groups throughout the country has influenced fertility. Such a correlation may exist, but it is not necessarily rational. The environmental and ecological concerns may translate themselves into a lower fertility because of a perception that we have too large a population. This is based on experience of local crowding, on air pollution and water pollution which is observed in the urban environment, and on the rapid urbanization of countryside in the vicinity of metropolitan centers. Traffic snarls, inadequate parking, and similar annoyances produce an impression that we have at least exceeded optimum population concentrations for portions of the United States. We may have, but on the other hand, we may not have. All these items are really evidence of a poor distribution of population, of poor planning, expecially in the field of transportation and land use, and of inadequate abatement of pollution.

But whether the arguments are rational or not matters little. The effects may be there, and they are certainly in the direction of diminishing fertility. A powerful impulse towards smaller families comes from the awareness of environmental and ecological problems, as well as from the realization that certain resources, such as fossil fuels, open space, wilderness areas, beaches, etc. may be finite after all.

Overall, one would judge that there have now appeared irreversible trends which have affected the decisions of millions of individuals towards having smaller families. These decisions are based on the expectation that thereby they will derive a higher quality of life, although their definition of "quality of life" is never spelled out and depends on individual perception. Nevertheless, it is remarkable that the sum total of these millions of individual decisions can result in a societal situation leading to zero population growth and a situation in which societal welfare as well will be benefited—in addition to individual welfare. In essence, people who are attempting to maximize their personal happiness may in the process also improve the state of societal economic and social welfare.

## *Urbanization of Population*

Christakis points out another dominant trend that needs to be seriously acknowledged. This is the dynamic evolution of human settlements into continuous urban systems. Some observers, such as C.A. Doxiadis, believe that urban areas may merge into a continuous universal city or "Ecumenopolis":

> "(Ecumenopolis) is the inevitable future of Human Settlements in the next few generations, as we can foresee that, assuming we avoid any major catastrophe, we will have to deal with a universal city whose population will tend to be stable in numbers but increasingly more developed intellectually and socially, which will dispose of much greater quantities of energy and achieve greater social interaction" (18).

The trend towards the Ecumenopolis is particularly dominant in emerging post-industrial societies such as the United States. The metropolitan area growth of the United States has been consistently more rapid than the increase of national population during the 20th century. Measured as a percentage of national population, metropolitan areas in 1960 contained 66 percent of the nation's population. By 1970 this percentage had increased to 71 percent of the national total. This meant that the United States was transformed from a country that was 60 percent rural in 1900 to one that was more than 70 percent urban in 1970. By the year 2000, based on trends of 1940-1970, 85 percent of the nation's population is projected to reside in major metorpolitan areas.

The most startling feature of projected population growth and distribution is that the majority of Americans will most likely live in giant metropolitan regions along the seaboards and the Great Lakes. In 1960, the United States contained 23 *great* metropolitan areas of one million or more people, each amounting to a total population of 68.2 million—38 percent of the national total population. The 1970 census reveals that the number of such metropolitan areas has risen to 29 and the population residing in metropolitan regions to 89.3 million or 44 percent of the national total. If these trends are extended to the year 2000, the proportion of the population residing in metropolitan regions of one million or more will amount to 65 percent (under the series B projection of the U.S. Bureau of the Census, amounting to 321 million people by the year 2000), residing in 50 such large urban agglomerations.

## Effects of Urban Overpopulation

In discussing the effects of urban overpopulation, Molitor says there is a growing body of evidence that animal overcrowding produces psychotic behavior. Fruit flies do over populate to extinction in Bell jars, lemmings do take periodic death plunges into the seas.

Sheer density has undersirable effects on social behavior. In dense urban-industrial areas, behavioral responses to overcrowding may help explain exploding criminal behavior, increasing group disorganization, even the growing incidence of mental disorders. Instead of a "nice to have luxury," there may be a biological necessity to relieve urban environmental pressures and to restore (19):

- —quiet (freedom from excessive noise pollution);
- —privacy (limits on invasion by electronic surveillance, systematic computerized data collection, etc.);
- —independence (mechanisms to relieve system breakdown from overdependence);
- —initiative (constricted by the mob's crush);
- —open space (green belts, recreation areas).

Population policy is increasingly becoming a public concern. Population policy once largely left to undirected decisions is "now on the verge of becoming a public concern, as a result of the dangers of overpopulation and the possibilities of avoiding them that are inherent in new birth control technologies" (20). One of the central problems is that there is no precise method of determining "optimum population."

Though environmental hazards posed by urban-industrial density are substantial, caution should be taken to avoid over-reacting. Current mood and sentiment verges on an "alienation hysteria" (21). The Population Commission final report cautions that, "An attitude of indifference of complacency (toward population growth) is unwarranted, so is the cry of early catastrophe and crises."

Christakis summarizes changes in life style brought about by the shift to urban living. He states that urbanization has caused major economic, social, and environmental changes for both the receiving metropolitan areas and the people left behind. As recently as the turn of the century, some 35 percent of America's workers were involved in agriculture. Today only 4.4 percent of the labor force is employed in agriculture and that figure is projected to decline to two percent by the year 2000. Employment in goods-producing industries such as manufacturing, construction, and mining has also been continuously declining relative to the total employment since the 1950's when the post-industrial or service economy emerged. Around 1956, the service-producing industries (trade, finance, services, real estate, public utilities, transportation, and government) took the lead over jobs in the goods-producing industries. When this happened, the U.S. became the first nation in the history of the world where the number of manual or blue-collar workers was exceeded by the so-called white-collar occupations. It appears that the policy implications of this *shift* have not yet been completely analyzed and explored by policy scientists.

The continuous eclipse of traditional industrial pursuits, i.e., agriculture and manfacturing, and the rise of the service-producing industries within a continuously growing metropolitan population, bring on a whole array of significant *shifts* that will profoundly affect the business structure, our daily life styles, and our value systems. Some of the basic *shifts* that are well under way are:

- From primary and secondary industries (agriculture/manufacturing) to tertiary and quaternary industries (service, knowledge activities).
- From goods to services.
- From goods/services produced by muscle power to those produced by machines and cybernetics.
- From the materialistic to the sensate.
- From "things" to experiences.
- From physiological to psychological needs.
- From scarcity to abundance and eventually to super abundance.
- From a few stark choices to a bewildering array of choices.
- From durability to disposables and planned obsolescence and back to recyclables, reclaimables.
- From self-interest motivation to a broader social and humanitarian outlook.
- From independence and self-sufficiency to interdependence.
- From individual freedom, to voluntary restraints, to mandatory restraints.
- From Puritan hard-work ethic to leisure as a matter of right.
- From Darwinian self-survival to humanistic security.
- From atomistic to large-scale pluralistic institutions.
- From national to multi-national and "one-world" scale operations.
- From decentralization to centralization and eventual globalization.
- From irrational chaos to futures-creative long range planning.

## Can Man Adapt to Urban Living?

Molitor believes that living organisms and even man-made institutions have a tendency to specialize and proliferate to the point where extreme demands bring on ultimate demise—entropy. Catastrophic collapse brought about by over-population, or any other excess, can be postponed or avoided altogether by *adaptation*. *Adaptability*—that has been the secret of man's mastery over the environment.

On the European Continent during the 14th century, as large urban cities emerged and grew, the Bubonic Plague wiped out some 25 percent of the entire inhabiting population (22). Man was unprepared. Adapting the human organism to large social complexes tested the mettle of then-existing technology and organizational skills. The stakes, literally, were life or death. Man did adapt. Sanitation and public health measures were developed and prevented epidemic spread of communicable diseases.

Natural growth limits for organisms depend upon the ability of getting rid of wastes—"this is what limits the size of a colony of bacteria on a nutrient surface" (23). In urban-industrial complexes limitations are similar. Adjustment is necessary if large-scale populations in urban industrial areas are to thrive.

Today, new adjustments to the giant-sized urban industrial habitats man has created are required. There are suggestions that man's physical health may be jeopardized by ecological imbalances in overly-stressed environments.

Man is what he consumes, and he consumes (24, 25):

—3 pounds of food solids;
—4 $^1/_2$-6 pounds of water;
—30-60 pounds of air.

Substantial changes in urban air and the water supplies have come about since the industrial period onward. Considerable evidence indicates that physical health itself may be imperiled by changes in the air we breathe, the water we drink, and the new environment. The peril will increase and unless appropriate corrective measures are taken, over-population and over-industrialization may over-tax ecologically balanced systems.

Developing knowledge suggesting population density may create disruptive social and psychological stresses, and that confrontations with air and water pollution are becoming increasingly hazardous, may be evolutionary handwriting on the wall.

One commentator suggests that genetic science may provide a means for "fitting men" to the environmental conditions—"fitting of the survivors," instead of survival of the fittest (26). Thus, instead of aiming our efforts at changing environmental factors, science and public policy could *accept* environmental circumstances and merely adapt man to cope with his changing environment. In all likelihood, both adaptation of the human organism *and* environmental adjustments will be required for survival.

Buckminster Fuller poses the following statistics implying man's numbers are manageable and that the population explosion is overstated (27):

- —man lives in "scattered patches covering less than 5 percent of the earth's surface";
- —"all the cities of our planet cover sum-totally less than 1 percent of the earth's surface";
- —megalopolises cover less than one-half of 1 percent of the earth's total surface."

Dramatically making his point, Fuller contends that as of 1965, "all humanity could be brought indoors in the buildings of greater New York City, each of us with as much floor room as at a cocktail party."

That is one cocktail party I hope to miss!

Census Bureau domestic calculations based on the 1970 Census, estimate distributing U.S. population equally over all 50 states would result in a density of about 57 persons per square mile. Similar calculations based on 1960 data estimated 50.6 per square mile. New Jersey with 953.1 persons per square mile was the most densely populated state; Alaska, with some 2 persons per square mile was the least densely populated (28). Population density based on 1970 Census data for all urbanized areas (central cities over 50,000 population) was 3,376 persons per square mile (29).

Regardless of the validity of these statistics, they underscore the point that urban density is the real crisis point. In this respect, the most populous metropolitan areas in the world—Shanghai (10 million), Tokyo (8.8 million), New York (7.9 million), Peking (7.5 million), and London (7.4 million)—are the cauldrons of change. The full force and effect of population implosions in these areas should be carefully studied to ascertain prospects for mankind. As other areas reach similar size and density, they should be able to benefit from experience in these precursor jurisdictions.

## *Environmental Effects of Population Growth*

From the information presented in the previous section, it is clear that the U.S. population will continue to grow, even if the birth rate remains at or below the ZPG rate. Further, shifts in the regional population distribution, especially moves to urban areas, will create urban and regional population pressures. As the national and regional populations grow and change, the respective economics will grow and change.

The resource and environmental consequences of a growth in population and economy are not totally predictable. The state of the science of demographics is such that we are not certain to what extent, and in what directions. The U.S. population and economy will grow, especially over the long-run. As we have seen, there is considerable evidence that the nation has achieved a ZPG rate, though this is offset by other factors, such as the high incidence currently of young women capable of bearing children. Further, should a ZPG rate be achieved, can it be maintained?

Nevertheless, it is possible to arrive at close approximations of the effect on the environment—particularly on the nation's natural resources—of any specified growth pattern. Given the assumption, then, that the U.S. is about to experience, or has experienced already a ZPG rate, what can be said about its effect on the environment?

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## A Classical Model for Environment and Population

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Christakis presents a simple classical model of the environmental impact of population and concludes, from study of the model, that uncontrolled growth can cause serious environmental damage, even under conditions of ZPG. One of the principal reasons for this conclusion is population density, i.e., urbanization. He also discusses results obtained by analysis with another model.

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Christakis' model is developed from a relationship of the form (30).

$$W = APq \qquad (1)$$

where

$W$ = pollutants emitted during a period
$P$ = total population of a geographic entity
$q$ = per capita output
and $A$ = a proportionality constant

To transform the quantity W to a spatial concentration C of pollution, or what is normally known as pollution levels, one must introduce the volume V of the medium in which the wastes are placed. One also needs to take into account the natural ability of the environment to cleanse itself through various biochemical processes. Hence, the rate of change in concentration at a point in time t will be the sum of what is added to the environment and what is subtracted because of the cleansing, i.e.,

$$dC/dt=(W/V)-rC \tag{2}$$

where $r$ is the rate at which the particular medium cleanses itself. By integrating Equation (2) and setting the integration constant equal to K one obtains, after substitution from Eq. (1),

$$C=(APg/Vr)(1-\exp(-rt)) + K\exp(-rt) \tag{3}$$

The adverse environmental impacts, or damage D, can be considered as a function of concentration C, i.e.,

$$D=f(C) \tag{4}$$

Our present state of knowledge of the functional form relating environmental damage to population and output (i.e., the feedback effects) is very limited. Also, the positive and negative synergisms that might exist between different pollutants at different levels of concentration is not yet known. Following a simple analytic approach, the per capita damage d is set proportional to the concentration C, the proportionality constant B itself being assumed to be a monotonically increasing function of the concentration of pollutants,

$$d=BC=f(C)C \tag{5}$$

The total damages, D, can then be represented by

$$D=BCP \tag{6}$$

Substitution of Equation (3) leads to

$$d=(AB/Vr)(1-\exp(-rt))qP + BK\exp(-rt) \tag{7}$$

and

$$D=P\Big((AB/Vr)(1-\exp(-rt))qP + BK\exp(-rt)\Big) \tag{8}$$

Defining a "volume" population density $p=P/V$, one can rewrite Equations (7) and (8) as

$$d=(k/r)(1-\exp(-rt))qp + BK\exp(-rt) \tag{9}$$

and

$$D = P\Big((k/r)(1-\exp(-rt))qp + BK\exp(-rt)\Big) \qquad (10)$$

where K is in general a coefficient whose numerical value depends on the concentration level and the amount of capital invested in pollution abatement facilities.

Equations (9) and (10), although very approximate and simplistic, enable one to make a number of useful observations concerning the environmental impacts of such factors as (1) the size of the population, P, (2) the geographic distribution or concentration of the population, p, (3) the amount of production (or consumption) per capita, q, i.e., the "affluence" variable, and (4) the amount of pollutant generated per capita of production (or consumption) k, which is essentially a variable reflecting technology and abatement policies. One can see, for example, that the damage to the environment D increases in proportion to the population P, the per capita output q, and the population volume density, p. If per capita output and population density are held constant, Equation (10) tells us that pollution is directly proportional to population. But if population were held constant, pollution could just as well increase, either because of increases in population volume density, or because of increases in per capita output. Hence, in this simple formulation, one is led to the conclusion that "uncontrolled" affluence, and "unplanned" metropolitanization of population can cause environmental damage even at zero population growth (assuming no fundamental changes in production and pollution technology). It is noteworthy that such a simplistic analytic model has confirmed our intuitive knowledge of the gross relationships between population, economic growth, and environmental degradation.

The accuracy and reliability of the simple analytic model leading to Equation (10) is limited. Realizing this limitation, the Commission on Population Growth and the American Future commissioned Resources for the Future (RFF) to develop an elaborate and highly disaggregated computer model for the purpose of analyzing the environmental impacts of alternative population and economic growth projections (31). The RFF approach consists essentially of an industrial input-output model coupled to exogeneous information derived on the basis of four alternative demographic and economic scenarios: high population and economic growth (Census Bureau series B-High GNP), low population and economic growth (Census Bureau series E-Low GNP) and the two intermediate cases (B-Low and E-High). For each one of the four scenarios the model calculates: (1) the main economic indicators, (2) estimates on resource requirements, (3) estimates of pollution levels under different assumptions regarding abatement policy and available technology and (4) the regional and metropolitan area impacts of air pollution.

Employing this model the RFF study arrives at a number of policy-oriented findings. Some of the most conclusions are paraphrased below (32).

(1) For the time horizon of the study, i.e., the next 30 to 50 years, the changes in technology, tastes, institutions, policies, and international relations will play more important roles than population growth in determining resource adequacy and environmental quality.

(2) For the time horizon of the study, a change in population growth appears to have a smaller impact on resource consumption than a change in economic growth. A one percent reduction in population would reduce consumption of resources in the year 2000 by 0.2 to 0.7 percent, whereas the equivalent percentage reduction in per capita GNP would reduce consumption in that year by 0.6 to 3.5 percent.

(3) The United States appears to be in good shape relative to other countries, provided we have sufficient lead time to develop domestic alternatives to foreign sources, should the need arise. A slower population growth rate leading to a stable population within the next 50 to 75 years, will buy us time to overcome our ignorance of ecological processes and expand our options in deciding how we want to live in the future; a slowdown in population and economic growth would clearly help in this respect by giving us sufficient lead time.

(4) The relative position of the poorer two-thirds of the world is likely to deteriorate further during the next 30 to 50 years unless some dramatic technological breakthroughs, rapid declines in birthrates, or massive transfers of resources from richer countries take place.

(5) While there is mounting evidence that environmental quality is lower in metropolitan areas that are more densely populated, the underlying causes for the lower quality may not be scale but factors such as: urban forms and transportation systems more appropriate to an earlier era; old, unintegrated service facilities; inappropriate pricing of public facilities and common property resources such as roads and waste disposal; multiple political jurisdictions; and the factors leading to inadequate financing and a predominance of minority groups and poor in the core cities.

Christakis points out that models such as the one described above should also provide for analysis of social issues. Later we will present his suggestions for methodology to achieve this end.

## Economic and Welfare Implications of ZPG

Singer has developed a different demographic-economic model (33). This model calculates a "per-capita welfare index" or a "Q-index" as a function of various demographic and economic parameters. In the following, Singer discusses the implications of a situation of increased welfare in which all members of society have some money left over for discretionary spending.

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If we can maintain our level of population near optimum, then it appears that each generation will become better off than the preceding one. In fact, maintenance of optimum population may mean, and almost certainly will mean, a declining level of population, but declining at a very slow rate.

The burning question, of course, centers on how people will choose to spend their income. In essence, we are really asking what life styles will people adopt for the future. There are, of course, several possibilities and any one of these, or any combination, may hold true. It would be useful to list these possibilities in order.

1. *More Leisure.* People may choose to take their greater welfare in terms of more leisure time. We have existing trends that show not only fewer working hours per week and fewer working days per year, but also fewer working years per lifetime. People today retire at an earlier age and also enter the labor force at a later age then they did some decades ago. There is no reason to expect that this trend will not continue, although, leisure, like every other good, has a decreasing marginal utility. By this is meant that the first hour of discretionary leisure time is much more valuable than each succeeding hour; beyond a certain point leisure time may not be very worthwhile to some people. These points have been considered in the model.
2. *More consumer goods.* In the future, it is quite likely that people will spend more on luxury goods. Such goods include second homes, third homes such as vacation cottages, beach houses, etc., vacation trips of more elaborate dimensions.
3. *More services.* Spending on a variety of services is one of the strongest existing trends and has also been incorporated in the model calculations. Naturally, it cannot continue forever, that is, services can never constitute 100 percent of all expenditures. We cannot run a country or the world by taking in each other's laundry. But we can certainly lavish a great deal of effort on such items as better health care, specialized education, cultural activities, as well as visits to psychiatrists.

4. Finally, the model considers the possibility of *increasing public investments*, not only in conventional public works designed to improve the working of the economy, such as highways, flood control projects, irrigation projects, etc. but also in environmental quality and conservation projects. These investments by their very nature have to be made through government, i.e. on a collective basis, with everyone contributing through tax payments, and presumably everyone benefiting somewhat in the relation to the payment of taxes.

As for any investment, public investment raise the question of cost-benefit analysis. Not only is it necessary to quantify the benefits (it is usually quite easy to quantify the costs) but there are additional and very serious problems when most of the benefits accrue to future years and perhaps to future generations. We know that a benefit today is worth more than one in the future, quite apart from any inflationary trends which can presumably be accounted for. We can take a benefit today, expressed in dollars, and invest this sum of money and arrive at a larger value in the future, simply because it has been invested.

One of the consequences flowing out of the results of the model calculation is the greater availability of funds for investments of all sorts because of greater discretionary income. Under a situation where capital becomes less scarce, it is possible to think of a situation of lower interest rates as well. But a lower interest rate, a lower return on invested capital, also means an enhanced value for future benefits. Under these conditions, it becomes attractive to consider diverting larger amounts of investments into projects which will yield benefits beyond the immediate ones, and benefits even into the far distant future.

Essentially, we are saying that with larger discretionary income there will be a larger propensity to invest in projects that benefit future generations, as well as in projects that lead to enhancement of current recreational benefits.

Under these conditions, it is possible to visualize an effort through political action to increase levels of environmental quality, both by setting higher standards, as well as by undertaking restoration projects. Not only does it become worthwhile and profitable to undertake such major programs as soil conservation, and control of agricultural pollution, separation of urban sewer systems into sanitary and storm sewers, dealing with acid mine drainage, but large scale restoration projects, also become more feasible: restoring the quality of the Great Lakes by appropriate remedial measures, restoring natural areas and wildlife habitats, reforestration, and reclamation of stripmined land, etc.

To sum up: with a projected increase in discretionary income we can look forward to a simultaneous increase in a number of unrelated activities: more leisure will be taken, more luxury goods will be bought, more services will be required, and large scale public programs will be undertaken not only to protect but also to improve our physical and social environment.

## Resource and Environmental Consequences of ZPG

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Ridker discusses the resource and environmental consequences of population and economic growth and the results of the RFF study mentioned in a previous section. In his discussion, particular emphasis is placed on the effects of ZPG. He reviews the determinants of resource and environmental pressures. Then he presents the consequence of growth as determined in the study using the RFF model and comparing those results with results obtained from more detailed and conventional studies of specific factors such as energy and agriculture. Population forecasts for high birth rate (Bureau of Census Series B, birth rate 3.1) and low (ZPG) birth rate (Series E, 2.1) were combined with several levels of economic growth. The new series F forecast, of course, was not available at the time of the study. His discussion is presented in the next section.

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### Determinants of Resource and Environmental Pressures

To begin, we must identify the factors that are most influential in determining resource requirements and environmental pressures. Changes in any of these determinants can significantly alter the nation's requirements for natural resources and they can just as significantly affect the quality of the environment. These determinants are usefully grouped under seven headings:

—*Demographic variables.* The size of the population, its rate of growth, its age structure, the number and size of the households involved, and the labor force participation rates: all have a bearing on the resources. They directly affect the level of consumption goods purchased, the types of goods purchased, as well as the level of economic activity we can expect from the population. This economic activity, of course, is an important determinant of the output of materials we can expect.

—*Standard of living.* Measured by per capita GNP or per capita income, the standard of living plays a similarly important role in determining the output of materials. Moreover, the distribution of the standard within the population is a separate, but related, factor of great importance.

—*Geographic distribution.* The distribution of the population and of the nation's economic activities bear heavily on resources and the environment. They are obviously important in explaining environmental pressures in given areas. They affect the cost—in terms of natural resources—of efforts to overcome these environmental pressures. Transport requirements between persons and producing units in various places exert further resource and environmental pressures.

—*Technological methods.* The methods used at each stage of economic activity, from mining and energy conversion through transport and production, to emission and treatment of effluents, can make a great difference in the character and magnitude of the problems we will face as a consequence of population and economic growth.

—*Life styles.* The role of life styles—preferences for leisure and for various kinds of commodities and ways of using them—reflect directly on the state of the environment and on the availability of natural resources. Certainly, a style of life that includes throwaway bottles, suburban living and high compression automobiles places vastly more pressure on the environment than does one that involves less emphasis on packaging and advertising, urban apartment living, and mass transit.

—*International considerations.* A sixth set of factors, which is sometimes overlooked but which is likely to play an increasingly important role in the future, pertains to international developments. In particular, the terms at which the United States can acquire resources and finished commodities from abroad are crucial in environmental and resource-availability considerations.

— *Policy.* Finally, all the above factors are influenced by policy: by rules and regulations for managing effluents and land use, by important policies with respect to fuels and minerals, by decisions made with respect to location of public investments, and so on.

## Population

At the outset let us recall that under any reasonable assumption about births-per-women during the next few decades, the population of the United States will grow quite substantially during the next quarter to half century. If ZPG is taken literally to mean a cessation of population growth, we are still far from achieving it. There are three reasons for this. First, the United States has a relatively young population, with a large fraction of women just entering childbearing years. Even if these women decide to have no more than the 2.1 children necessary for replacement, this age structure will result in population growth by nearly 40 percent before stability is reached. Second, to achieve ZPG immediately, U.S. women would have to have an average of only slightly more than one child for some decades into the future, at least until the age distribution corrects itself. While it is true that fertility and expectations about completed fertility among young women have fallen sharply in the last five years, the most recent survey on birth expectations reports that women 18-24 expect to complete their childbearing years with an average of 2.1 children, a far cry from the 1.2 or so necessary to achieve immediate ZPG. Put in terms of birth rates, to achieve ZPG and sustain it over time the crude birth rate would have to fall from 16 to less than 10 per thousand and remain there for some decades, an event that appears highly unlikely in the near future. Third, all the above ignores net immigration which has been set by law at 400,000 per year. This figure is more than 20 percent of the natural increase in population in recent years. There is no reason to believe that it will decline in the near future.

What has happened in recent years is a decline in fertility and fertility expectations that sets the stage for the ultimate achievement of ZPG, or something very near it. Between 1957 and 1969 the total fertility rate has steadily fallen, the five-year averages from 1955-59 through 1965-69 being 3.69, 3.46, and 2.63. Today, this figure probably stands at around 2.1.

### Standard of Living and Life Style

While it seems quite likely that life styles will change significantly during the next half century, it is not at all certain that they will be in the direction of conserving on resources, unless official policy dictates such a course.

Consider the preference for savings over consumption. The personal savings rate might rise if with growing opulence and fewer children we become sated with goods and services, or if we channel increasing portions of our incomes into housing (for example, second homes). But the expectation of routine prosperity and economic security guaranteed through extensions of unemployment, health, and old age and survivors insurance is likely to dampen individual incentives to save. So too would the persistence of secular price inflation. Increased leisure would also operate in the same direction, increasing consumption especially of recreational goods and services. On net these trends may mean less personal savings. But this is a trend that can be offset by business and government savings behavior. Provided we are willing to let businesses and government save for us, long-term growth prospects need not be seriously affected by this shift in preferences.

So far as shifts in preferences among types of goods are concerned, there seems to be some evidence to indicate a shift from private to public goods and services, and within each category from goods to services. Since cross-section consumption studies indicate that the income elasticity of demand for services and many types of public expenditures tends to be higher than for other kinds of goods, there is some reason to believe that such shifts will continue in the future as incomes rise. But a large fraction of public goods involve construction and a significant component of what are called consumer services involves transportation, both heavy users of resources, especially of energy.

A significant shift in preference for leisure over work could have a major impact on resource requirements, at least so long as this shift is not offset by increased automation that results in more goods to be enjoyed during the increased leisure hours. In recent years, work hours per year have ceased their slow, long-term decline. In addition, increasing numbers of women have been entering the labor market. One possible explanation is the need for additional income in the face of the price inflation of recent years. But these changes seem to be independent of family income. Indeed, often it is the wives of well-off husbands who appear most eager to give up leisure for work. An alternative explanation may be that for many in our society work has ceased to be considered a "bad" to be avoided to the extent one's income permits. Perhaps, over time the workplace is offering increasing numbers of nonmonetary as well as monetary benefits: a pleasant physical environment, interesting, "meaningful" things to do, friends, status, respect—and sufficient on-the-job leisure to take advantage of these opportunities. As machine-paced labor is replaced by more automated processes, and as jobs for more intrinsic interest increase in number, this phenomenon is likely to become more and more important. So far as the economy and resource needs are concerned, the result is almost the same as if off-the-job leisure increased, except that it shows up as a decline in man-hour productivity rather than as a decline in work hours or labor force participation rates.

To account for these possible changes in preferences, the following assumptions are made: no change in the overall propensity to consume and save, a continuation in the trend towards services and public goods, and shifts in the composition of consumer purchases that arise from changes in the numbers of families in different age, income, and family size classes. Two alternative assumptions about labor productivity and work hours can then be considered. First, man hour productivity can be assumed to continue growing at 2.5 percent per year and annual work hours to decline by 0.25 percent per year, more or less on trend. As a second alternative the effect of a decline in work hours by 1.0 percent per year can be considered. While still far from a zero economic growth case, the shift towards leisure implied by this second, low economic growth case is fairly dramatic: instead of weekly work hours falling over a thirty-year period from 40 to 37 in the high growth case, they would fall to 29 in the low growth scenario.

It should be noted that the equivalent low growth case can be generated by assuming a fall in the growth of manhour productivity to 1.5 percent per year while holding to the first assumption about annual work hours. Considering the possibility of on-the-job rather than off-the-job leisure increasing, this may be more realistic, but in no way does it change the analysis.

### Technological Changes

Five types of technological changes should be distinguished. The first, overall changes in labor productivity, has already been considered. The others involve changes in materials used per unit of output, changes in the generation of residuals per unit of output (or per unit of materials input), changes in the emission of wastes per unit of residuals generated, and changes in pollution per unit of wastes.

So far as materials other than energy used per unit of output are concerned, the trend has been distinctly downward. Twenty years ago a ton of peaches would produce 40 cases of canned fruit; today 55 cases can be produced from one ton. In addition, the composition of materials has changed dramatically, energy and capital substituting for labor, cheaper materials substituting for higher cost minerals, chemical fertilizers and pesticides substituting for land and natural manures. There is no reason to believe that such changes will not continue in the future, although the particular direction they will take is difficult to predict.

In general the amount of wastes generated per unit of materials input has also been improving. For example, in 1943, the production of container board generated 0.45 tons of waste per ton of final product whereas by 1963 this figure had dropped to 0.21. For the economy as a whole it is difficult to generalize because of the introduction of new processes, products, and materials over time.

The third type of technological change, changes in the emission of wastes per unit of residuals, has to do with the extent of recovery and recycling. Here the picture is mixed, the trend since World War II involving less recycling of waste paper and more recycling of a number of metals. The principal factors influencing these trends are changes in the geographic distribution of the sources of wastes—for example, suburbanization trends that make collection of waste paper more costly—and relative prices which are, of course, subject to influence by government policy. Considering the fact that the incentives for recycling and recovery have been few in the past, it seems quite likely that there is considerable scope for improvements in these directions.

The last category of technological change involves the form in which the wastes are emitted. In large part, this has to do with pollution treatment technology, but change in production processes can also have a significant effect on the toxicity of the wastes. Over time, as the chemical industry has learned to synthesize compounds not found in nature, and hence in general not readily assimilated by plants and animals, the situation has worsened. Treatment technology, however, has been improving and with the proper incentives can be expected to continue improving.

The projection of this mixed bag of effects is, of course, very difficult to project without introducing technological fixes that may never happen; one must figure it very conservatively, permitting ongoing changes to work their way out but not introducing much that is new. Ongoing substitution of one material for another in particular uses—e.g., plastic for metal in pipe production—are permitted to continue up to some specified maximum, and today's best practice is assumed to become the average practice in each industry by the year 2000. But new processes, substitutions, and products, with both their good and bad effects, have for the most part been left out.

## Geographic Distribution

By now the principal trends in distribution of population and economic activities are well known and documented: the emptying out of the countryside, the rapid territorial spread of metropolitan areas, and the reduction in population densities in many central cities. A continuation of these trends is likely to result in an increase in the percent of the population living in metropolitan areas from 71 percent in 1970 to 85 percent in the year 2000 and an increase in the geographic area classified as urban from 200 square miles in 1960 to 500 square miles by 2000. By the latter date, this would mean that one-sixth of the land area of the United States (exclusive of Alaska and Hawaii) would be devoted to urban settlement (34).

But these trends are heavily dependent on a number of policies. While it is difficult to predict whether densities will increase or decrease in the Washington, D. C. metropolitan area as a consequence of the introduction of both a subway and a frequently proposed tax on downtown parking, there can be no doubt that such changes will have profound effects. To account for such changes, at least insofar as air pollution is concerned, several alternatives to this basic trend have been considered: one requiring that 10 percent of the additional economic activity that might otherwise locate in metropolitan regions be located outside these area, another restricting the geographic spread of current metropolitan areas, and so on. Several of the results obtained are presented in the analysis.

## International Developments

Unfortunately, far too little time has been devoted to the study of international trends of importance for the United States. Basically, the Bureau of Mines "high" projections for minerals and energy consumption in the rest of the world can be accepted at face value and it can be assumed that a relatively free trade regime would prevail. This could give quite misleading results, especially so far as the energy picture is concerned.

### Policy Changes

In order to highlight the effects of population and economic growth, in most of the basic scenarios studied the policy regime is assumed to be constant as of about 1967-70. But several variations of an "active abatement policy" were also explored and are reported on below.

### The Consequences of ZPG

The implications of these determinants and our assumed changes in them over time were examined in two ways: first using a mathematical model of the economy designed to highlight the resource and environmental elements under study, and, second, comparing these results with those obtained from more detailed and conventional studies of specific sectors such as energy and agriculture. Those results that are most salient for the discussion of policy and research implications are presented below.

### The Economy

To simplify the task, four basic scenarios were developed from the set of alternative assumption with which we worked: a high population-(Bureau of Census Series B) high economic growth (denoted H) case (B-H), a low population (Bureau of Census Series E)-low economic growth (denoted L) case (E-L), and the two intermediate cases. We started by assuming no change in resource or environmental policy from the base period. Table 2 presents the results.

As can be seen, by the year 2000 the U.S. economy will be somewhere between double and triple its current size, with all that entails for resource and environmental pressures. A slowdown in population growth will help, of course: it results in a higher per capita income and a smaller GNP, that is, greater per capita material welfare with a smaller output of materials. But even with a significant shift towards leisure—and despite the shift towards services built into these projections—it is clear that we shall face much greater resource and environmental pressures in the future than we have so far.

### Resource Adequacy

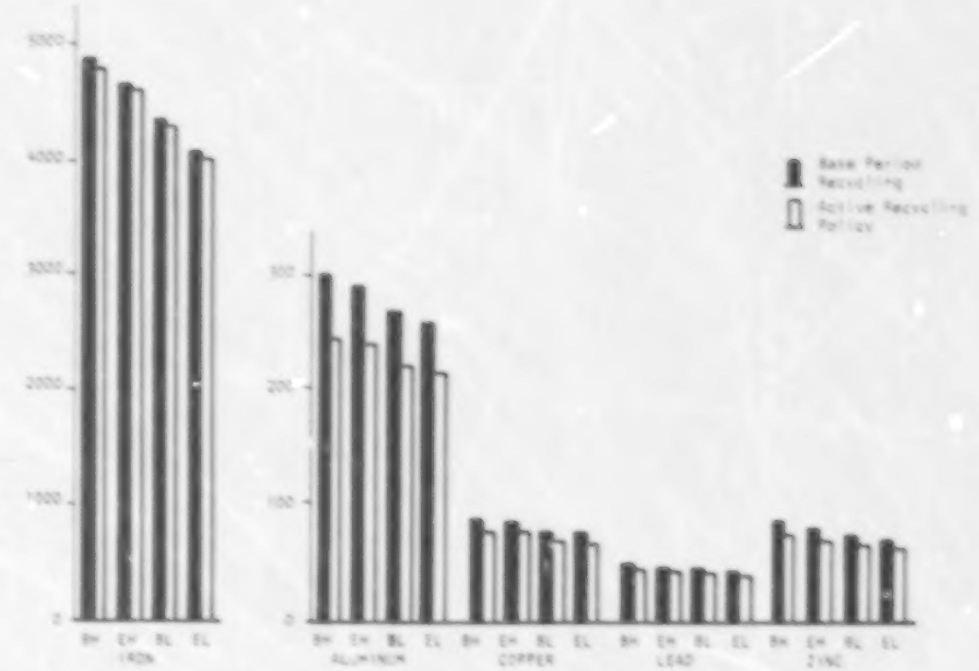
Figure 3 presents a picture of the total amounts of five of the 19 minerals studied that are needed to achieve these basic scenarios between now and the year 2000. The bars representing an "active recycling policy" reflect our judgment about the additional amount of recycling (over and above what was already present in the base period) that should be feasible given current technology and proper incentives. For these minerals, as well as for the others studied, the slowdown in population growth is not as effective in saving on resources as is a reduction in economic growth, but the combination of both plus an active recycling policy can achieve a considerable

## Table 2 Demographic and Economic Indicators for Alternative Population and Economic Assumptions, No Policy Change

| Indicator | 1970 | Absolute Figures | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2000 | | | | 2020 | | | |
| | | B-H | E-H | B-L | E-L | B-H | E-H | B-L | E-L |
| Population (millions) | 205 | 321 | 266 | 321 | 266 | 440 | 299 | 440 | 299 |
| Labor Force (millions) | 85 | 136 | 127 | 136 | 127 | 186 | 166 | 186 | 166 |
| Households (millions) | 62 | 106 | 101 | 106 | 101 | 145 | 173 | 145 | 173 |
| GNP Per Capita (1967 $) | 3937 | 8125 | 9098 | 6452 | 7218 | 12661 | 14625 | 8632 | 9946 |
| Disposable Income Per Capita (1958 $) | 2595 | 5399 | 6018 | 4261 | 4721 | 8650 | 9868 | 5806 | 6558 |
| GNP (bil. 1967 $) | 807 | 2608 | 2420 | 2071 | 1920 | 5571 | 4373 | 3798 | 2976 |
| Consumption (bil. 1967 $) | 524 | 1704 | 1577 | 1339 | 1237 | 3747 | 2899 | 2514 | 1930 |
| Investment (bil. 1967 $) | 99 | 341 | 309 | 228 | 252 | 688 | 551 | 497 | 400 |
| Government (bil. 1967 $) | 186 | 579 | 548 | 468 | 442 | 1170 | 948 | 813 | 659 |
| Defense (bil. 1967 $) | 62 | 97 | 102 | 88 | 92 | 169 | 158 | 128 | 133 |
| Non-Defense (bil. 1967 $) | 124 | 482 | 446 | 380 | 350 | 1001 | 790 | 685 | 526 |
| Net Exports (bil. 1967 $) | -3 | -17 | -15 | -13 | -11 | -33 | -25 | -22 | -16 |
| Total Output (bil. 1967 $) | 1326 | 4174 | 3843 | 3336 | 3064 | 8900 | 6933 | 6124 | 4767 |
| Primary (bil. 1967 $) | 84 | 207 | 192 | 176 | 161 | 406 | 318 | 297 | 231 |
| Mining (bil. 1967 $) | 22 | 59 | 57 | 49 | 47 | 119 | 100 | 87 | 72 |
| Construction (bil. 1967 $) | 57 | 181 | 166 | 148 | 133 | 382 | 296 | 276 | 209 |
| Manufacturing (bil. 1967 $) | 585 | 1776 | 1628 | 1437 | 1316 | 3689 | 2877 | 2587 | 2012 |
| Food (bil. 1967 $) | 93 | 214 | 198 | 184 | 170 | 405 | 317 | 306 | 236 |
| Paper (bil. 1967 $) | 22 | 73 | 66 | 58 | 53 | 155 | 119 | 107 | 82 |
| Petroleum (bil. 1967 $) | 26 | 60 | 62 | 51 | 57 | 115 | 105 | 87 | 76 |
| Chemicals (bil. 1967 $) | 45 | 152 | 142 | 120 | 112 | 321 | 254 | 218 | 173 |
| Primary Metals (bil. 1967 $) | 44 | 122 | 111 | 100 | 90 | 251 | 197 | 180 | 140 |
| Rubber and plastics (bil. 1967 $) | 14 | 54 | 48 | 43 | 38 | 117 | 98 | 80 | 60 |
| Stone and Clay (bil. 1967 $) | 14 | 48 | 43 | 39 | 35 | 101 | 79 | 76 | 56 |
| Textiles (bil. 1967 $) | 25 | 69 | 60 | 57 | 46 | 140 | 103 | 89 | 65 |
| Lumber and Wood (bil. 1967 $) | 12 | 41 | 39 | 36 | 31 | 92 | 71 | 61 | 49 |
| Leather (bil. 1967 $) | 4 | 14 | 10 | 11 | 7 | 31 | 20 | 20 | 12 |
| Services (bil. 1967 $) | 600 | 2009 | 1858 | 1575 | 1456 | 4426 | 3442 | 2966 | 2295 |
| Electricity (bil. 1967 $) | 19 | 72 | 66 | 58 | 53 | 164 | 127 | 116 | 88 |
| Consumption Purchases (bil. 1967 $) | 524 | 1704 | 1577 | 1339 | 1237 | 3747 | 2899 | 2514 | 1930 |
| Durables (bil. 1967 $) | 52 | 207 | 188 | 159 | 144 | 478 | 362 | 314 | 236 |
| Nondurables (bil. 1967 $) | 128 | 333 | 313 | 278 | 261 | 667 | 525 | 482 | 377 |
| Services (bil. 1967 $) | 344 | 1164 | 1076 | 902 | 832 | 2602 | 2012 | 1718 | 1317 |

*% increase from B-H

SOURCE: U.S. Commission on Population Growth and the American Future, Population, Resources, and the Environment, Ronald G. Ridker, editor, Vol. III of Commission Research Reports (Washington, D.C.: U.S. Government Printing Office, 1972), adapted from Table 7, p. 41.



*From U.S. Commission on Population Growth and the American Future, Population, Resources and the Environment, op. cit., p. 97.

Figure 3. Cumulative Requirements for Five Metals. Basic Scenarios With and Without Active Recycling Policy, 1968-2000 (million tons)

saving. Unfortunately, at this juncture we could not evolve a clear idea of the cost in economic or environmental terms involved in this much recycling.

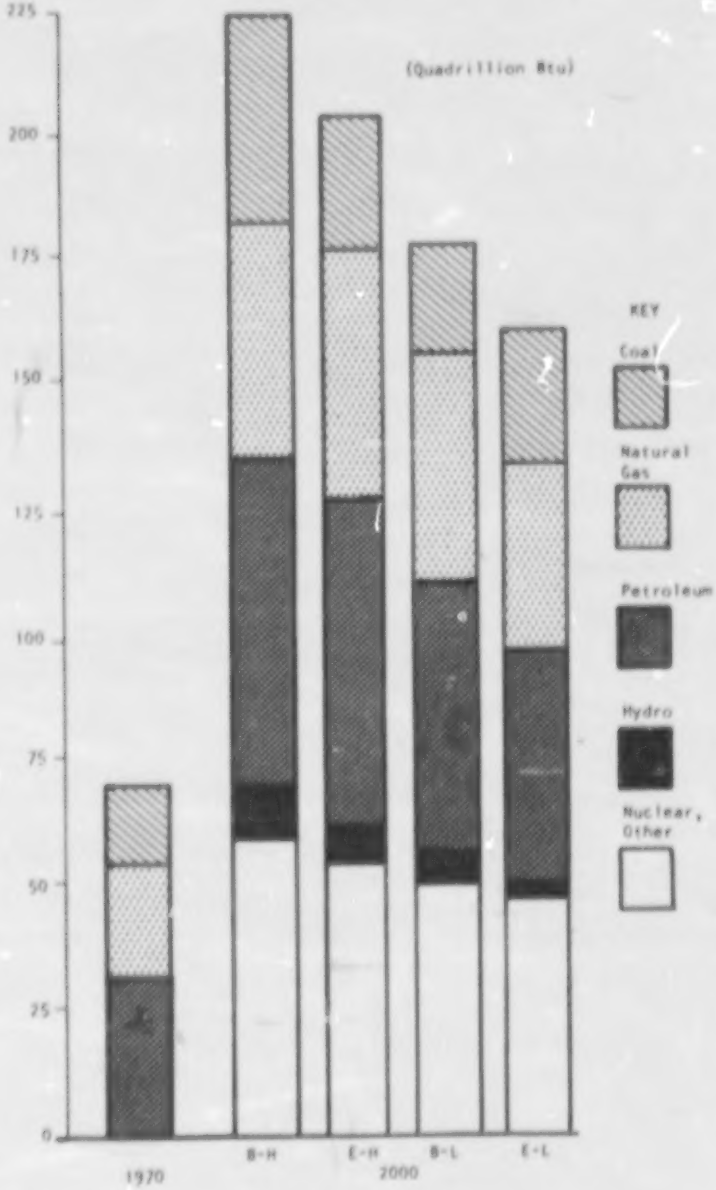
Figure 4 presents a picture of annual energy requirements. Because it assumes only modest changes in energy technology from the base period—an assumption that is rapidly becoming outdated—the breakdown by fuels is probably not very significant. For example, gasification of coal will probably be necessary before the turn of the century to meet some of the natural gas requirements. But the breakdown does indicate in general terms the extent to which we shall continue to be dependent on petroleum.

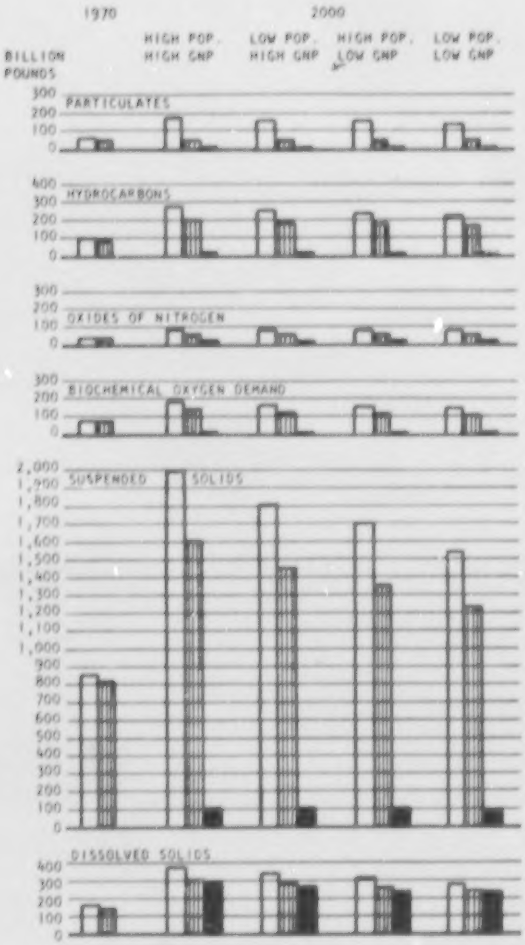
When these requirements projections are matched against supply projections for the United States and against demand and supply projections for the rest of the world, the principal conclusion that emerges is that the United States is not likely to experience any truly serious shortages during the next quarter to half century solely as a consequence of population and economic growth. By "serious shortages" are meant shortages that would cause the relative price of a significant number of these minerals and fuels to increase by more than 50 percent or so. Other factors may of course come into the picture to upset this conclusion, a point that must be amplified later. Environmental groups may refuse to permit the construction of a sufficient number of nuclear or other electric power plants or the Organization of Petroleum Exporting Countries may successfully impose monopolistic control over a large fraction of the world's petroleum supplies. But strictly as a consequence of population and economic growth in this country and perhaps also in the rest of the world, the United States is likely to be able to find the necessary supplies to meet rising demands without price increases of such a magnitude that the general welfare is endangered.

## Pollution

Figure 5 illustrates our findings with respect to a number of different pollutants. The bars labeled A represent the amount of various pollutants generated in 1970 and likely to be generated in the year 2000 under alternative assumptions about population and economic growth. The bars labeled B in 1970 indicate the amount of these pollutants emitted, the difference between A and B indicating the small amount of treatment present in that year. The bars labeled B in the year 2000 indicate the amount of various pollutants likely to be emitted in that year assuming the same level of treatment as in 1970 but taking into account the changes in technology that are likely to come along even in the absence of an active abatement policy. In principle, such technological changes could result in either a higher or a lower level of residuals per unit of output; in fact, however, most of the changes investigated reduce residuals. To a large extent, this result

Figure 4. Annual Requirements for Energy, Basic Scenarios. (Source: "Population, Resources, and the Environment," op. cit., p. 43.)





□ Pollution generated assuming 1970 technology associated with pollution. (Technological changes resulting in substitutions amongst inputs--e.g., plastics for metals--are included.)

▥ Pollution emitted in 1970 and in 2000 assuming charges in pollution generation coefficients and efficiency of treatment likely to come along even without an active abatement policy.

■ Emissions in 2000 assuming use of production and treatment processes induced by an active abatement policy.

Active abatement in this case means secondary treatment which has no appreciable effect on dissolved solids.

Figure 5. Pollution Generated and Emitted Under Alternative Assumptions

arises from the assumption that best practice in 1970 becomes average practice by the year 2000; while this assumption by itself is very conservative, we purposely left out new processes and products that might come along to raise new problems.

To arrive at the bars labeled C, representing an active abatement policy, EPA's recommended emission standards for 1975 were applied. While it appears likely that the technology will exist by 1975 to meet these standards, we applied them in the year 2000, by which time, at least from a technological point of view, it should be possible to surpass them.

As far as can be judged the cost of meeting these standards does not appear excessively expensive. In 1970, the annualized costs of pollution abatement were estimated by EPA to be $8.45 billion (1967 dollars), about one percent of GNP. To meet the emission standards implied by this active abatement policy, it is estimated that these costs will have to rise to between $34 billion (for the case E-H) and $47 billion (for the case B-H) by the year 2000 (all figures in 1967 dollars). While these are, very large numbers, they still amount to less than two percent of GNP in the year 2000. To make room for such expenditures we would have to give up less than one-tenth of one percentage point in annual growth of GNP. Once again, however, there are some qualifications which must be brought up again in discussing policy implications.

It should be noted, however, that the pollutants that were studied for the most part have relatively short half-lives. Because of data and other analytical problems, radiation, heavy metals, persistent pesticides, and similar pollutants that can accumulate in the environment over time were not studied in as much depth.

## Regional Problems

A second qualification to the analysis of pollution problems arises from regional concerns: some regions could face serious problems even though they achieve the 1975 emission standards. To determine whether this is the case, regional projections were developed for three air pollutants in 47 cities and applied to a general air diffusion model.

Table 3 summarizes the results for a special case in which the land area of each city expands in proportion to its population increase, thereby keeping density constant. As can be seen, a growing number of cities will not be able to meet the ambient standards without the active abatement policy(35).

For these two areas, both of which are already above the nitrogen dioxide standard, something must give: the use of the internal combustion engine, inmigration of people and activities or the standard itself. While

Table 4. Number of Cities Among 47 Studied Not Meeting Specified Ambient Standards

| | 1970 | 2000 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | No Policy Changes | | | | Abatement Policy | | | |
| | | B-H | E-H | B-L | E-L | B-H | E-H | B-L | E-L |
| $SO_2$ (80 micrograms)[a] | 2 | 2 | 3 | 1 | 1 | 0 | 0 | 0 | 0 |
| $SO_2$ (60 micrograms)[a] | 4 | 6 | 6 | 4 | 5 | 0 | 0 | 0 | 0 |
| $NO_2$ (100 micrograms)[a] | 36 | 41 | 43 | 41 | 42 | 2 | 3 | 2 | 2 |
| Particulates (75 micrograms)[a] | 36 | 27 | 32 | 15 | 19 | 0 | 0 | 0 | 0 |
| Particulates (60 micrograms)[a] | 44 | 42 | 43 | 32 | 37 | 0 | 0 | 0 | 0 |

[a] Annual arithmetic mean in micrograms per cubic meter

SOURCE: U.S. Commission on Population Growth and the American Future, Population, Resources, and the Environment, Ronald G. Ridker, editor, Volume III of Commission Research Reports (Washington, D.C.: U.S. Government Printing Office, 1972), Tables 10, 11, and 12, pp. 52-56.

Washington, D.C., was not included among the 47 urban areas in this sample, a recent study suggests that the same situation applies here as well. It is likely that more detailed studies of other metropolitan areas and other pollutants will provide additional cases of this sort.

If we assume that urban land area expands less rapidly than population, the situation worsens rapidly. On the other hand, when in one run of this model it was assumed that 10 percent of the additional economic activities that would otherwise have located in these urban areas were instead required to locate in nonurban areas, the situation improved only marginally, reducing the number of cities not meeting the sulfate standards from two to one and the number not meeting particulate standards from 27 to 17, while those not meeting the nitrate standard remained the same.

A final point of interest about these regional projections is their great diversity. Population density is increasing in some while it is decreasing in others. For sulfates in 1970, the highest average concentration level for any city is six times that of the lowest. Even with an active abatement policy, some areas will grow worse over time while others improve. Moreover, the trend is not the same for all three pollutants: particulate levels are likely to fall in a number of cities even without an active abatement policy while nitrate levels are likely to worsen in some even with such a policy.

## *The Policy Implications of Zero Population Growth*

It appears obvious that the historical trend cannot continue in which successive doublings of world population require only half the time of the prior doubling. Still, it is possible for the world population growth to continue at a slower rate of increase than at present for many years, subject to the constraints of food production, availability of energy, and availability of natural resources. An earth population numbering as many as 35 to 50 billion has been considered possibly by some forecasters.

As we have seen, the world population could be stabilized into a ZPG state at some desired level, as one alternative. Or, a phase of declining population or "negative population growth" could ensue. A third alternative is that of continued growth.

Calhoun considers these alternatives from the viewpoint of the "evolution of consciousness." (See Chapter 6.) It is his contention that if ZPG is the choice, the capacity of the individual human will stay as constant as the rate of population increase itself. There will be no further evolution of consciousness; evolution for humans will have been terminated. It will be all over except for a "continuous hedonistic traditionalism."

Other animals have had this choice thrust upon them and have persisted for millions of years. Calhoun notes the same possibility for humans, but warns that only through our own intent and deliberate actions can we alter the pattern and allow the evolution of our consciousness to continue.

During the current domain of evolution, the total worth of humanity has progressed according to the product of the population and the capacity (or consciousness) of the average individual. This total worth of humanity, which Calhoun terms "ideomass", has steadily increased, despite the fact that the "biomass" (or product of population and average body weight) became constant.

If population is allowed to increase to the limits possible, according to Calhoun, then the average individual would become less aware of less and less, until most individuals had dropped below the level of consciousness required for initiating cultural evolution.

## Policy and Research Implications

Ridker discusses two implications for policy and research. He believes direct measures for dealing with resource shortages and pollution are superior to the indirect measures of population control and control of the economy. Secondly, he suggests that more comprehensive approaches to problem solving should improve our environmental situation with less social and economic cost. His discussion follows.

## Direct versus Indirect Approaches

It has become commonplace in the last few years to hear calls for ZPG and ZEG (Zero Economic Growth) as ways to contain the encroachment of man on the earth's limited supplies of raw materials and environmental carrying capacity. In contrast to measures like zoning, effluent charges, and mass transit, such policies would operate indirectly on our resource and environmental problems. They are said to be necessary because the direct measures are only palliatives, attempting to correct the symptoms rather than attacking the main causes.

So far as population growth is concerned there is little argument. Even if there were no necessity for such growth to cease, its continuance provides us with no social advantages and a number of costs at this stage in our history. But the same cannot be said about economic growth which, with appropriate changes in composition, can be utilized so solve many of the problems it creates. The question of whether it must also cease is of more interest.

There can be no doubt that all population and economic growth must someday cease. Exponential growth in a limited space cannot continue forever. Technological advance can postpone that ultimate day, but it cannot repeal the laws of nature. But this fact by itself is of little relevance. Far more important is the question, when? Must it cease within our lifetime, that of our grandchildren, or some far-off distant generation? It makes an enormous difference for policy today how we answer this question.

Unfortunately, the information does not exist with which to answer this question, except to say that there is no reason why it must cease within the next 50 years or so. Beyond that point, we must admit ignorance. We do not know what kind of disasters we may be letting ourselves in for by permitting economic growth to continue, but we are also ignorant of possible technological and institutional breakthroughs that may come along not just to save future generations from disaster but perhaps to make them substantially better off than the current generation. For the time being, therefore, we can still choose whether to slow growth down as a way of coping with our problems or to rely on more direct attacks on the problems that face us.

Within this fifty-year time frame, our analysis strongly suggests that as policy instruments for dealing with raw materials shortages and pollution, direct measures are far superior to across-the-board restrictions on population and economic growth. The clearest indication of this is found in Figure 5 which compared the reductions in pollution that might be achieved using direct and indirect approaches. Other examples can be found by comparing the amount of reduction in GNP per capita that would be necessary to curtail the emission of a given pollutant, say sulfur oxides, by a given amount, with the extent of the reduction in GNP per capita that would occur as a consequence of a more selective approach. Analysis indicates that a one percentage point reduction in GNP per capita would reduce this pollutant by 0.87 percent, but that if the output of the five sectors with the highest emission coefficients were reduced by 2.5 percent this same 0.87 percent reduction in sulfux oxides could be achieved with only a third of a percentage point reduction in GNP per capita. An even more dramatic example would involve a direct attack on the automobile, which by itself accounts for 12 percent of hydrocarbon emissions, 60 percent of carbon monoxide emissions and 25 percent of nitrogen oxide emissions from all manmade sources. The same argument applies to resources, at least to resources in general: given the substitution possibilities that are present, why reduce the consumption of all resources because a few are in short supply?

Of course, such direct approaches will result in some slowdown in economic growth. But with the exception of a few especially vulnerable regions, the extent of this slowdown is not likely to be great during the next quarter to half century. Beyond this period, it is possible that measures which bite more heavily into aggregate economic growth will prove necessary. But that is as it should be. So long as other options are available, including the option of changing the composition of growth, there is no sense in limiting aggregate economic growth until we have to.

### Piecemeal, Restrictive Measures versus Structural Changes

A more difficult issue involves the question of which direct measures to use. All that Figure 5 suggests is that we have the technological know-how to reduce future emission levels at reasonable cost, despite the population and economic growth that will occur in the interim. It does not say that policies can or will be devised to accomplish such reductions. This would not be the first time that we accomplished far less than we know how to do.

Most of the measures in use today, especially in the environmental field, can be characterized as restrictive in character. The imposition of standards that must be met by a future date is perhaps the best example. Even effluent charges, or full-cost pricing, which for good reasons most economists favor, are restrictive in the sense that the person faced with the charge is induced to restrict his own behavior to reduce the burden of these addititional costs. While it is somewhat more difficult to characterize resource policy in this same way since subsidies for research and exploration are also part of the scene, it is certainly the case in both the resource and environmental fields that most of our policies are not integrated into any overall framework that considers all the ways of skinning the cat and all the consequences of doing so by different methods. To illustrate the kinds of problems that can arise from such piecemeal, restrictive approaches, we take an example from the energy and urban transport fields, first considering the resource and then the environmental sides of these interrelated problems.

On the basis of the assumptions incorporated into the study, there appear to be adequate supplies of petroleum to meet the world's needs during the next half century or so, if not considerably beyond. One might be inclined to predict from this that our current energy system based on liquid petroleum fuels can continue for some time to come.

But it is not difficult to make a case to the contrary. Consider a few of the problems the United States will face in the energy field during the next 10 to 15 years. Suppose that the OPEC cartel becomes stronger and decides to set its long-term price on the basis of the costs of producing alternative sources of petroleum in the United States, rather than in relation to its much lower costs of production. The choices for the United States would involve reliance on imports—with all the attendant balance of payments, political, and military risks that would entail—attempts to break the cartel through the application of colonial policies—which we as well as the Europeans may have lost the will if not also the capacity to adopt—or efforts to reduce our long run dependence on foreign oil. Most likely the United States will try to opt for this latter course.

But the production of oil from offshore sources, tar sands and shale, will involve serious environmental problems, problems that will not be resolved cheaply, quickly, or to the satisfaction of many local groups with the power to hold up developments. On the basis of this scenario, either environmental concerns will be subverted or the lifespan of our liquid energy system will be short, despite the existence of adequate worldwide supplies.

The alternatives on the supply side are to develop coal gasification, and nuclear, solar, and geothermal sources of electricity. Some of these alternatives raise new kinds of environmental concerns, perhaps the most serious being the need to store highly lethal, radioactive wastes from breeders in ever-increasing amounts for literally thousands of years. But in any event, unless significant changes occur in our transport system, the extent to which gas and electricity can be substituted for liquid fuels will be quite limited. Sooner or later we shall have to look for alternatives on the demand side, that is, alternatives which reduce our need for liquid fuels. If we do so by restrictive means, for example, by permitting the price of fuel oil and gasoline to rise significantly, considerable hardships will result for an extended period of time, until structural changes in our transport system, commuting patterns, and the layout of cities are forced to occur. If we anticipate these structural changes, at least by building them into all new urban developments, many of these hardships can be ameliorated.

A similar conclusion emerged when the study focussed on the environmental problems of a number of regions. At least two urban areas in the sample of 47 will not be able to achieve the ambient standards set by EPA, solely through the use of emission controls on internal combustion engines; and more detailed studies of other cities and pollutants are likely to provide additional examples. The standards may be too stringent and should be relaxed. But when we add in the problems of auto congestion consequent on the growth of populations in urban areas during the next half century, it seems highly probable that restrictions on the use of the private automobile in many central cities will be necessary in any event. Once again, planned structural changes in city form, commuting patterns, and mass transit systems will be required to achieve an orderly and timely transition.

The principal purposes in presenting these examples are to demonstrate the need for more comprehensive approaches to the problems we face and to suggest a situation in which more resource conservation and environmental improvement may be possible at less economic and social cost through planned technological, institutional, and urban design changes than by the application of the more traditional approaches of regulatory agencies. The latter may ultimately induce the same changes, but the social cost of doing so is likely to be much higher. Of course, to apply this approach one must know in advance just what structural changes are needed, and then must find some way to implement them.

### Research Implications

Given the above discussion and our obvious ignorance about the consequences of alternative courses of action that may profoundly affect our lives, many research needs practically suggest themselves. Comments here are limited to just five points which are more in the nature of caveats than specific suggestions for research, but which nevertheless are quite important in the formulation of detailed projects.

*Long-term comprehensive planning.* There can be no doubt about the need for careful, interdisciplinary study of the kinds of problem sets discussed above, where questions of resource adequacy and environmental quality overlap and are mediated by developments in fields as disparate as international politics and urban design. Often, the researcher's response to problem sets of this kind is to suggest more comprehensive simulation models.

The principal problem with such models is that we know exceedingly little about physical, biological and social responses to changes in environmental and other factors we wish to study. Before our level of confidence can be increased to the point where such models become more useful in the policy formation process, vastly more information on basic relationships is needed.

This is true even in the environmental field, narrowly defined. What, for example, is the relationship between a given rate and duration of effluent emissions into a water body and ambient concentrations of resulting chemical compounds in that body; what is the relationship between such concentrations and effects on plant and animal life associated with this water body; once man is directly or indirectly affected, how will he adapt to these changes; and how is he likely to assess the costs of such changes in his environment and adaptive behavior? Similar and vastly more difficult questions can be asked about behavioral relationships in other fields that should be included in such comprehensive models.

It will be along time before an acceptable level of confidence can be placed in many of the critical relationships. How can we satisfy the need for comprehensive, long-term planning in the interim? Perhaps the only thing that can be done is to rely on the judgment of mature and experienced persons, who come to these problems with a certain frame of mind: a willingness to consider and obtain expert advice on all important factors that can impinge on the problem, no matter in what field or specialty they occur; the ability to maintain a sense of proportions about the relative importance of these factors and the usefulness of various tools of analysis.

*Technological development.* Many of the constraints we are facing can be significantly pushed back in time by technological developments. But in many of the fields we are concerned with, these developments will not occur without public support and stimulation. Until recently, for example, there has been little if any interest on the part of private business in the development of alternatives to the internal combustion engine, alternatives to our dependence on petroleum, or technological and institutional systems for economical recycling, recovery and waste treatment. If these developments are to occur in a timely fashion, the Federal government will have to rethink its research priorities and provide significantly greater stimulus to technological developments, especially in the field of energy, than it has so far. Agencies concerned with environmental quality should, quite obviously, play a major role in this process.

*Environmental consequences.* As these technological changes occur, priorities for study of environmental consequences must also change. If some of the above judgments are correct, it is none too soon, for example, to devote far greater efforts to the study of the environmental problems of shale, tar sands, and coal gasification; the suggestion of standards and of methods for the control of these problems. Nor is it any too soon to consider the technical and institutional implications of the requirement to store vast quantities of nuclear wastes in perpetuity, should the decision be made to opt for the fast breeder on a large scale.

*Experimental approaches.* To obtain the behavioral relations that are necessary, complete reliance cannot be placed on empirical observations drawn from past experience or from cross-section studies; in many cases, we simply do not have past experience to draw upon. How, for example, can we estimate the behavioral response to a significant increase in taxes on downtown parking when commuters have not been faced with such a tax in the past? In such situations, the only way to obtain reliable information may be to encourage demonstration of an imposed tax and observe the results.

Admittedly, this approach raises extremely difficult practical problems. But there are a few areas in which this approach is currently being used, and with imagination it might be extended to others. A few experiments in the use of alternative fuels are under way; so too are some pilot programs testing out alternative systems of mass transit. These activities can and should be encouraged on a much greater scale. It should be possible to extend this approach to the development of alternative methods for establishing and implementing effluent charges and other monetary incentives in the environmental field. For example, local citizens groups representing all interested parties could be established to fix rates which would be subject to revision, upwards or downwards, depending on how they were working, to meet standards for environmental quality (laid down nationally or locally).

*Institutional Implications.* While the study reviewed above does not directly suggest many institutional implications, two suggestions can be raised in conclusion.

First, problems can be cut down to manageable size by splitting them up into their functional parts and dividing responsibility, or by treating them in smaller geographic areas. In the case of many environmental problems many of which must be handled in a fairly comprehensive way, geographic subdivision makes especially good sense. The great diversity we observed above in the experience that urban areas face and will increasingly face in the future lend weight to this suggestion. So too does the problem of appropriately reflecting the preferences of all interested parties in making decisions about zoning and other aspects of environmental quality.

What we have in mind is the establishment of regional environmental management agencies, with fairly comprehensive authority to set standards above certain national minimal levels, to levy charges, to guide and schedule the use of land, water, and air with respect to pollution emissions, and to the extent possible within certain overall guidelines, to reflect the interests of all relevant parties. *At a minimum,* such a region should encompass a whole metropolitan area, rather than just the central city or major suburbs within the region. I believe that a good start has recently been made in developing new institutions along these lines, it should be encouraged and promoted.

The second point is that consideration of the problems and prospects involved in this country's long-term future convinces most researchers that an important dimension of policy formation is being overlooked. This dimension involves the identification, study, and initiation of actions with respect to future problems that may require lead times of decades rather than years to resolve. There is a need for continuous monitoring and evaluation of the long-term implications of demographic changes, of future resource demand and supplies, of possible pollution overload situations and of the underlying trends in technology and patterns of social behavior that influence these factors, and once future problems are identified, there is a need to undertake the necessary research and development and formulate the policies to resolve them. While parts of these tasks are being performed by isolated agencies, coordination and analytical assessment on a broad level is lacking. Most government agencies are of necessity present-oriented or mission-oriented and sometimes do not serve these functions adequately.

nor can they be left to *ad hoc* commissions as we have tended to do so far. Thus, we conclude, there would seem to be a need for a small, strategically located public agency to serve as a "lobby for the future," with the responsibility for undertaking long-term strategic planning for the nation.

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# 3

# ANALYSIS OF ECOSYSTEM CAPACITY

## *Introduction*

An ecosystem is a set of living things and their environment. The system concept emphasizes the interdependence and interrelatedness of all elements of the ecosystem. The term and concept can be applied to systems of any size. A pond, a region or the complete biosphere can each be studied as an ecosystem. Whatever the size, an ecosystem has finite limitations. The natural resources, renewable and non-renewable, available to sustain life in any period of time are limited.

When we apply the ecosystem concept to a geopolitical region we see that the natural resources available to produce goods and services, Gross Regional Product (GRP), are limited. Given the inevitable population growth, accompanied by some economic growth discussed in the previous chapter, we see that ultimately some limit must be reached. Whether this limit is near or whether we should be concerned about a doomsday, we don't know. We do know that the public demands a high quality of life. This requires use of resources not only for goods and services but also for intangibles and amenities. Planners and decision-makers must address the problems of providing material goods and amenities to growing populations.

In the past the concept of carrying capacity has been defined as the ability of a region to sustain some population, usually a specific animal population. In this Chapter, we will apply the concept in a broader sense. We define carrying capacity as the ability of the natural resources of a region to provide material goods and services and amenities to a human population while maintaining some acceptable quality of life. With this definition carrying capacity analysis becomes a tool for planners and decision-makers to evaluate alternative goals and plans.

The discussion of carrying capacity analysis is taken from the invited paper by E. K. Peterson. He presents a method for establishing a benchmark standard for quality of life and evaluating alternative combinations of population, GRP and levels of pollution control. Using first approximation numbers, the concept is applied to the Pacific Northwest.

The carrying capacity analysis presented by Peterson is an example of the multidisciplinary analysis required to determine the relationships among the many factors influencing the environment and the Quality of Life. The need for such methodologies was discussed in the Study of Critical Environmental Problems (SCEP) sponsored by MIT in 1970. The major findings of this study are presented, in summary form, to introduce Peterson's paper. The "Spaceship Earth" concept is also described in the introductory material. This popularized model illustrates the finite limitations of our resources and the interdependence of all elements of the biosphere—facts of life which can be dealt with by means of analyses such as presented by Peterson.

The Study of Critical Environmental Problems was sponsored by MIT in 1970 as a means of providing information for the 1972 U.N. Conference on the Human Environment and for other environmental activities[1]. A total of 115 scientists, representing many disciplines, participated in the study. The major conclusions and recommendations of the study are presented below.

A major conclusion of the SCEP study was that data of all types are lacking and that new methods of collecting, compiling and standardizing data are required. Peterson's paper presents a first effort at compiling data describing the resources available for producing goods and amenities in the Pacific Northwest region.

The SCEP report notes that agriculture, mining and industry are increasing at a rate of above five percent annually, approximately twice as fast as global population growth. Man is using natural resources at rates greater than the rates of erosion and deposition; the distribution of resources is changing.

The gradual pollution-caused attrition of natural systems is a measure of the total impact of man on the environment. Most pollutants affect predators, specific species and general biological activities—all of which must be balanced to maintain a healthy ecology.

The SCEP recommends an intensive program of technology assessment to determine the effects of pollutants, to identify the sources of pollutants and to integrate such information into plans for technological development. It also recommends a program of environmental assessment to determine the distribution routes of pollutants and their passage through ecosystems.

In a broad sense the carrying capacity analysis presented here can be used as a tool for technology and environmental assessment. One such analysis of pollution as a function of regional production and population level is presented by Peterson.

Speaking of global climatic effects, the SCEP report states that man may affect climate by introducing, through fossil fuel combustion, carbon dioxide into the atmosphere. Recently, the carbon dioxide density has been increasing by about 0.2 percent per year. The study estimates, based on a "primitive model," that doubling the carbon dioxide concentration would result in an increase of about 2°C in surface temperature, which could lead to long term warming of the planet. The study concludes that climatic change as a result of changes in the carbon dioxide content of the atmosphere is unlikely in the near term, however, the long-term effects could be serious and continued study and monitoring are required.

Man introduces significant quantities of sulfates, nitrates and hydrocarbons into the atmosphere. The optical properties of these particles and how they scatter and absorb energy from the sun and the surface of the earth must be studied, improved measurement techniques must be developed and specific particle content must be monitored to improve our understanding of their impact.

The report emphasizes that the system of ocean and air currents, evaporation and precipitation, surface and cloud reflection and absorption, form a complex feedback system which maintains the global energy in balance. The delicacy of this balance and the consequences of disturbing it make it important to assess the present and future impact of man's activities on this system.

In summary, the SCEP report cites the need for more data and further study. It emphasizes the balance which must be maintained between the many factors influencing the environment. A further example of the limitations and interrelatedness of the biosphere is presented in the next section.

## *The Spaceship Earth Concept*

Comparing the earth and its life support systems to a spaceship is a vivid way of illustrating the finite nature of our ecosystem. As described by Lynton Caldwell (2), this model:

> "Illustrates relationships between man and his environment that are basic to his welfare and survival. Ecological facts that man prefers to evade on earth are universally acknowledged for the spaceship. For example, no one doubts that there is a limit to the number of passengers that the ship can accommodate, and the need for reserve capacity to meet unforeseeable contingencies is not questioned. It is obvious that the spaceship cannot indefinitely transform its nutrients into waste.
>
> If extruded from the ship as waste, energy sources are irretrievably lost; if accumulated as waste, viability of the ship is ultimately destroyed from within. There is no escape from the necessity of recycling waste materials. For the duration of the voyage, the ship must remain in ecological balance. Disruption of any of its systems may mean disaster for the mission and the crew. Systems maintenance is, therefore, one of the essential components of a program of space exploration."

Comparing the ecology of the spaceship to that of the earth, Caldwell says:

> "The ... (earth) is a unified system dependent upon the coordinated and continuing functioning of interrelating systems and parts. It has surpluses, redundancy, and backup capacity, but its resources are nevertheless limited. Because carrying capacity is one of its limits, it must so far as possible recycle its resources unless it can obtain them at feasible cost from external sources. Changes in the system must be studied in relation to their total effects, because altered relationships among the parts, even intended improvements, may adversely affect the performance of the whole. Maintenance of the system and its subsystems must be watched, for failure at any critical point could lead to the destruction of the entire enterprise."

## *Implications for Today*

The SCEP report discusses the balance which must exist among all elements of the biosphere and states that man has caused significant damage to the environment. It presents specific recommendations for improving the data available and recommends methodologies which must be developed to support environmental planning. The Spaceship Earth concept emphasizes the finite limitations of our resources and again stresses the interdependence among the elements of the biosphere.

Although these discussions focus on the total biosphere and global environmental problems, the SCEP report notes that the existence of global problems does not necessarily imply a need for global solutions. Most corrective action must be applied at the national, regional and local levels, where the sources of pollution and the activities of man can be controlled and regulated.

To control and manage the environment at the local or regional level requires information and data to define and quantify the factors affecting the environment. New methods of analysis which help planners and policymakers evaluate the probable results of alternative actions are required. The carrying capacity analysis presented by Peterson is one approach to such analysis. He presents data quantifying the resources available for producing goods and for producing amenities. The latter permits an evaluation of the Quality of Life available under alternative policies. He describes the relationships between population levels, production of goods and energy, pollution, pollution control and the Quality of Life.

## *The Classical Fundamental Problem of Population and Industrial Growth*

As a prelude to his discussion of carrying capacity analysis, Peterson summarizes relationships between population and industrial output as follows:

Frequently natural resource and environmental quality problems have been equated with population. However, human members are only one part of the equation. The other part is the goods and services (gross product) man produces with energy applied to machines. This energy may be derived from domestic animals, from hydro power, from burning wood or fossil fuels, from nuclear or direct solar sources. For a nation or a large region the consumption of natural resources and the potential detrimental impact on the environment is assumed to increase roughly in proportion to the increase in the gross product. However, there are variations in the potential impact from basic industries as compared to secondary industries, or between individual basic industries; also the relationship can be modified substantially by recycling and by other forms of pollution control.

Gross product also is assumed to vary in proportion to energy consumption. The relationship between income, gross product, and energy use, on an annual per capita basis for selected nations, is shown in Figures 1, 2, and 3. Although the relationship has been approximately correct in the past it is not necessarily inviolate for all time. But at present there is insufficient evidence upon which to base an assumption of a change. On a national basis there was a slight downward trend in the use of energy per unit of GNP between 1950 and 1968, but since then it has been rising.

### Per Capita Share of GNP

For convenience the per capita share of GNP in 1965 dollars, is used as the measurement of goods and services produced. In 1967 the situation in one affluent nation and and one underdeveloped nation was as shown in Table 1.

Table 1
Comparison of Per Capita Consumption[1]

| | United States | India |
|---|---|---|
| Per Capita Share GNP in 1967 | $3,490 | $88 |
| Energy Equivalent Required (tons of coal) | 12 | 0.25 |
| Steel (pounds per capita per year) | 1,300 | 30 |

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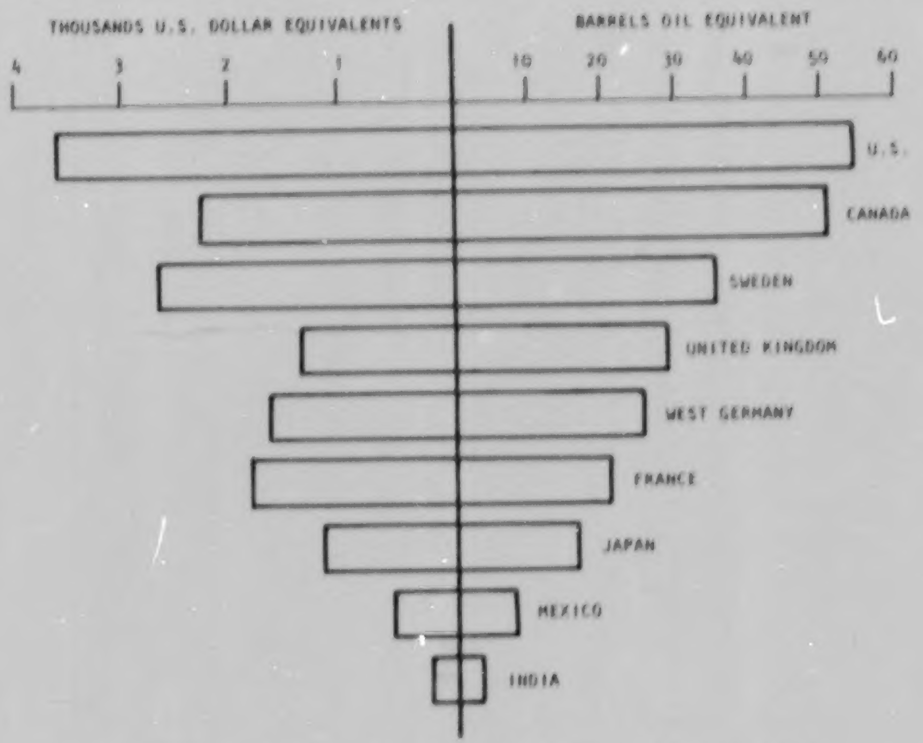
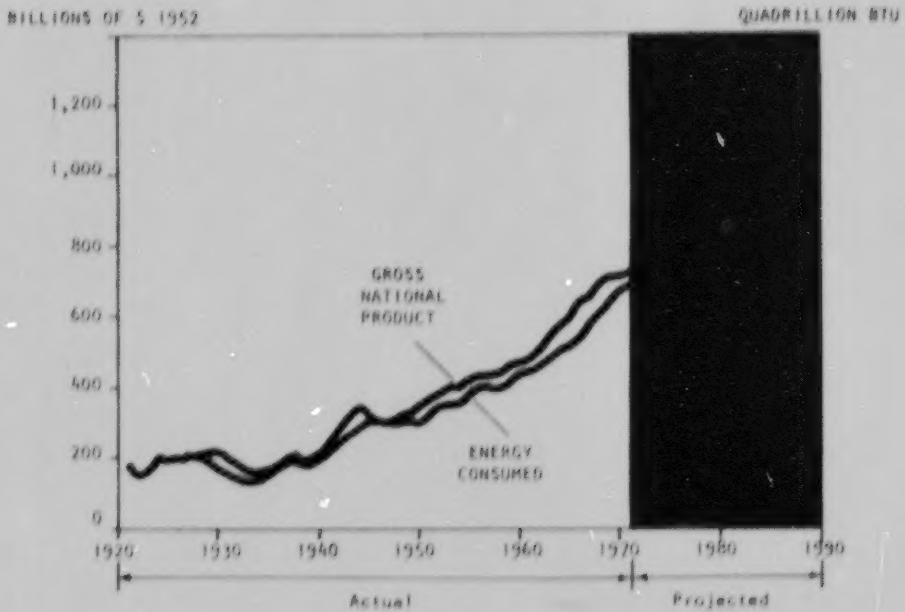
[1] "The Next Ninety Years," proceedings of a conference sponsored by the Office for Industrial Associates at the California Institute of Technology (1967), Harrison Brown, Professor of Geochemistry.



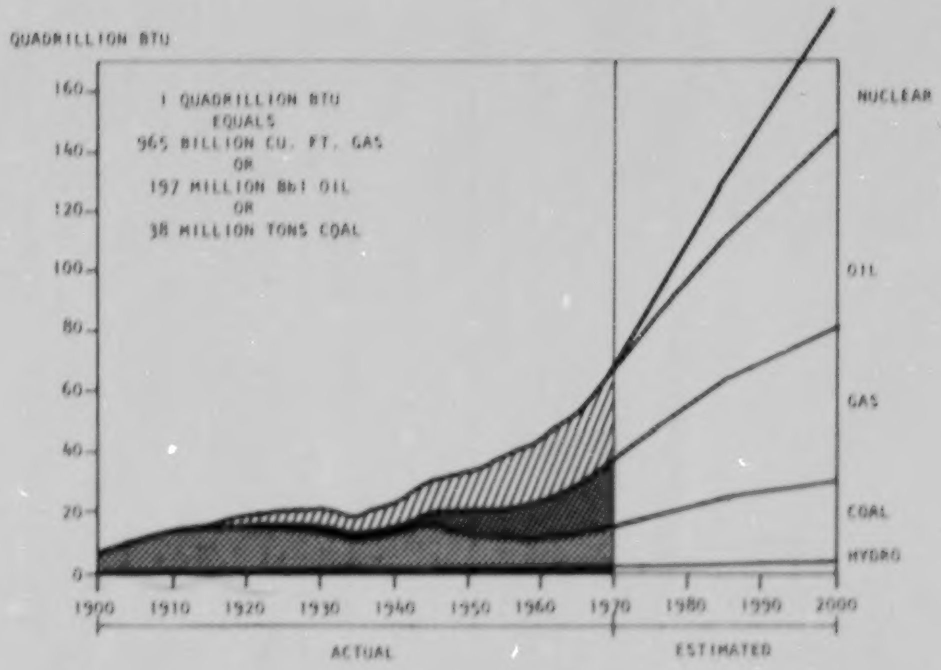
Based upon 1968 data. Standard Oil Company of California Bulletin, 1970.

Figure 1. Annual Per Capita Income and Energy Consumption



SOURCE: Office of Oil and Gas, Department of the Interior, March 1971.

Figure 2. Energy Use and Gross National Product



SOURCE: Office of Oil and Gas, Department of the Interior, March 1971.

Figure 3. U.S. Energy Consumption in the 20th Century

It appears clear that the total impact per capita upon the environment is much greater in industrialized countries such as the United States than in underdeveloped countries such as India. The latter uses far less land and natural resources, far less goods and services, and causes far less pollution on a per capita basis. In other words, in India most of the environmental stress is caused directly by the human population. In the United States, which has only moderate population density, the bulk of the environmental stress results from economic activity.

## Per Capita Servant Machines

A portion of the gross product is produced by unassisted human labor. Through the use of energy and technology the capacity of an average individual to produce goods and services multiplies as a nation becomes more industrialized. One way of illustrating the relationship is to assign a portion of the per capita production of gross product to humans and the remainder to their "servant machines" (3).

An exact dollar figure representing what an average person could produce without modern powered equipment (exclusive of domestic animals) probably cannot be established. In 1870, according to the Historical Statistics of the United States, U.S. Bureau of the Census, the per capita share of the GNP in the United States was $440, in 1965 dollars. Earlier statistics are not available. The 1870 figure probably was above the world base due to the very favorable natural resource supply situation and rudimentary industrialization. On the other hand the $88 figure for India in 1967 appears low for use as a worldwide base. Much of the economy of India, and other undeveloped nations, is barter and subsistence. This is not conducted through established markets and therefore not priced in national statistics. A figure of $250 per year appears to be a good compromise and more realistic. It would approximate 4 kilowatt years of electrical energy or the energy equivalent resulting from the combustion of about 1,700 pounds of coal. Lacking a more refined comparison, let us make this assumption. This would mean that in the Uited States in 1967, the average person had 13 "servant machines" ($3,490/$250 less 1) at his disposal—each "servant" producing as many beneficial outputs, and using as much resources and space and causing as much pollution in the process as its owner. This is without considering the amount of pollution control.

In comparison, a citizen of Sweden had 8.5 servant machines; Canada, 8; West Germany, 5.6; Japan, 2.8; Russia, 2.3; and mainland China or India, only a fraction (4).

In 2020, with increasing affluence, the number of servant machines is projected to increase to 61 per person in the United States. However, the end point of uncontrolled expansion is total destruction. Sooner or later we must achieve a sustainable balance between the rate we use and exploit basic resources and the capacity of the environment to support such use and abuse. As the British technologist, Dr. Dennis Gabor, expresses it (5):

> "Exponential curves grow to infinity only in mathematics. In the physical world, they either turn around and saturate or they break down catastrophically."

It is possible that, if environmental quality is to be maintained, the total number of humans that could be sustained in a given region would tend to decrease as individual affluence (servant machines) increases; or conversely, the greater the number of people at a given time the fewer there would be who could "live like kings." As Garrett Hardin in "Tragedy of the Commons" points out, Jeremy Bentham's 19th Century principle "The greatest good to the greatest number in the long run" is a mathematical and biological impossibility (6). The two variables cannot be maximized simultaneously.

## *Limitations of Classical Planning*

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Peterson believes that traditional methods of planning, based on extrapolation of historical trends is no longer adequate. We need a systematic method of identifying long-range goals and evaluating alternative plans.

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Concern in the past about comprehensive long range goals has been minimal. There is little understanding of the long term effects that different rates and kinds of growth would have on the quality of life. There has been little concerted action toward adopting coordinated long range goals as a formal state or regional policy. There is no agreement on what mix of material goals and intangibles are needed for the highest attainable quality of life. Each person, each corporation, each governmental unit, each citizens' organization historically has pursued his or its own ends. The result has been unplanned, uncoordinated and uncontrolled growth. This kind of growth historically has produced in the United States a high material standard of living. But it also is increasingly yielding undesirable environmental results.

### Classical Forecasts for the Pacific Northwest

The 1967 forecast of the Office of Business Economics, U.S. Department of Commerce, and Economic Research Service, U.S. Department of Agriculture (OBERS), to the year 2020 include a change in population for the Northwest region from 5.9 million in 1965 to 12.7 million (216%); and in per capita annual personal income, in constant 1965 dollars, from $2,785 in 1965 to $13,189 (474%). In per capita share of gross regional product, they project a change from $3,520 to $16,700. Such increases would result in 10.2 times the production of goods and services that existed in 1965 or from $20.4 billion to $208 billion in constant 1965 dollars. The 1971 projections based upon 1967 data show population in 2020 as 11.97 million and per capita income as $13,181, in 1965 dollars. These are shown graphically in Figure 4.

Similar forecasts, including some consideration of individual resource capability, frequently have been accepted by planners and decision makers as goals and are used to forecast the long range "needs" and "demands" for other national and local programs such as public lands and resources, transportation, energy supply, housing, health and education. The Battelle Memorial Institute and the Bonneville Power Administration used such methods for projecting Pacific Northwest long range growth in population, employment, and income.

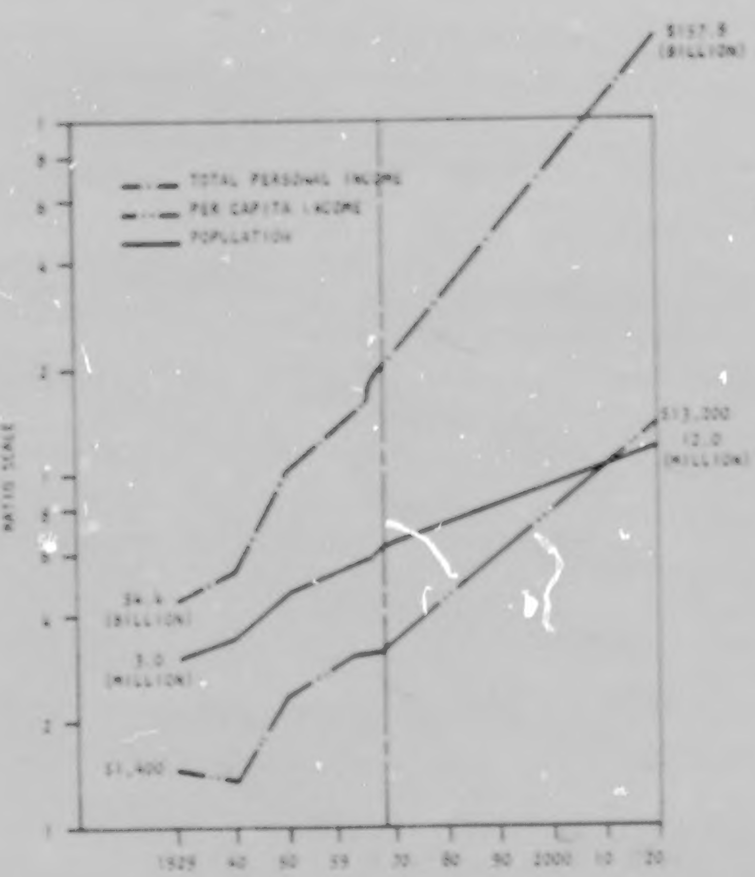
## Questions Unanswered by the Forecasts

This type of economic projection has proven to be a reasonably accurate forecast during the past 50 years and no other system for identifying goals has been readily available. However, it frequently ignores natural resource supply constraints, assumes unlimited growth, and fails to quantify either the combined capacity of all Northwest natural resources to sustain growth or the effect that the projected growth and economic development would have on the livability, the congestion, the air and water pollution, and the natural or the intangible values. Specifically, the following questions must be answered:

1. Would the result be mining without renewal of the natural resources?
2. Would the capacity of our natural systems to assimilate man-made waste be overwhelmed?
3. Would Northwest conditions in the year 2000 be comparable to conditions in 1972 in the Los Angeles area or the East Coast megalopolis?
4. Would people have a higher material standard of living but enjoy it less?

## New Concepts for Planning

To answer questions such as those posed in the preceeding Section and to incorporate alternative approaches to solving these problems, the study draws only slightly on either the pure ecologists or the economists, whether classical or contemporary. Instead it utilizes contemporary



SOURCE: Office of Business Economics, U.S. Department of Commerce, and Economic Research Service, U.S. Department of Agriculture (OBERS), 1967 base year (1965 dollars)

Figure 4. Pacific Northwest Growth in Total Personal Income, Income Per Capita and Population from 1929 to 1967, with Projections to 2020

multidisciplinary efforts that attempt to gain a balanced perspective of the two, such as:

"Tragedy of the Commons", Garrett Hardin, 1968. (6).

"Resources and Man", Preston Cloud, Ed., National Academy of Sciences. (7).

"Man's Impact on the Global Environment" Report of SCEP, sponsored by the Massachusetts Institute of Technology, 1970. (8).

"Population, Resources, Environment", Paul R. Ehrlich & Anne H. Ehrlich. (9).

"The Closing Circle", Barry Commoner. (10).

"A Blueprint for Survival", in *The Ecologist*, January 1972. (11).

"Report of the Commission on Population and the American Future". (12).

"Economic Growth and Environmental Decay", David W. Seckler & Paul W. Barkey. (13).

**Assumed Limitations to Growth**

Any function monotonically increasing in a positive non-fractional geometric progression will approach an infinite amount. This is commonly referred to as exponential growth. Since land and other resources are finite and since population and gross regional product increase in a geometric series, a limit will be reached if growth continues. One natural law that is as immutable as the law of gravity is that nothing physical on this planet can expand forever. Based upon these principles the assumptions are made that:

(1) It is physically impossible for either the gross regional product or the population to expand forever.

(2) A state of equilibrium must be reached eventually, the unknowns are when and how.

(3) At some point in time, further increases in population and gross regional product begin reducing the overall quality of life.

The foregoing assumptions challenge the American ethic—the doctrine of "manifest destiny"—of Keynesian economics—that growth is progress and progress is good—that the "invisible guiding hand" of the market place will automatically produce the optimum mix of material and intangible benefits. There has been relatively little scientific effort devoted to studying such basic issues (14).

Reluctance to tackle the basic issues directly may arise because it is contrary to the growth drive that has been United States gospel since 1776 and has in fact motivated much of mankind since prehistoric times. But changes in our way of life and the quality of living are increasing rapidly. Since 1950 the real output of goods and services in the United States has exceeded the total for the previous 330 years. What we do now, or fail to do, fixes future patterns of life. We can no longer afford to approach the future haphazardly. The choice is whether to plan for and guide future changes or be engulfed by them. This paper is devoted to exploring in a systematic manner one of the possible ways of identifying long range goals, using the Pacific Northwest as an example.

### New Assumptions for Planning Guidelines

Most of the planning assumptions to date have been that the future will be an extension of the past; that population increases and industrial growth inevitably will continue at an exponential rate and the proper course of action is to supply the highways, electrical power, water, urban expansion, and all other things needed to accommodate this growth; that plans are needed only to organize the inevitable; that any problems which result from the growth will be solved by using science and technology to manipulate natural ecosystems.

There is a rapidly developing differing view that (15):

(1) Today's problems are a result of successes as defined in yesterday's terms.

(2) An extension of the past is not the right prescription for the future.

(3) The primary planning goals for this nation should be altered—with high quality livability as the major long term objective (including a major improvement in the economic position of many of our citizens) and economic development shaped around this overriding determinant.

(4) Science and technology, if oriented toward harmony with nature, can, within limits, assist in reaching the highest attainable quality of life goals.

(5) Through social and political action it is possible to encourage, modify, or block growth and development trends so that they are compatible with those long range goals which are supported by a popular consensus.

Unquestionably, the attainment of the present United States material standard of living coupled with a high level of personal freedom and leisure time has been a magnificent achievement—the envy of much of the world. But there were unforeseen and costly consequences too. Now there are new challenges. The foresight exercised in today's planning decisions and actions (or lack of actions) will determine the quality of life and material standard of living available for our children and grandchildren. Land, water, and air resources must be recognized as inseparable components of a single life support system, not as independent reservoirs for both raw materials and waste disposal to be appropriated and exploited at will. Some way must be found to balance and harmonize both economic and ecologic goals while maintaining our democratic principles.

**Alternative Goals**

If the desire of the people is to control their own destiny and build a future which differs from an extension of the past it will be necessary to decide upon long range goals and tailor long range plans and action programs to best fit those goals. It would require changes in many of our traditional procedures and priorities. Among them is the system of preparing long range plans based primarily upon the projection of historical growth trends in population and economic activity.

We thus have four alternative fundamental growth policies we can adopt.

*Alternative one.* Arbitrarily adopt a "no growth" policy.

*Alternative two.* Make every effort to accelerate growth.

*Alternative three.* Combine several scenarios of pollution, natural beauty, living space, and other environmental quality trends with several alternate economic projections to present a better balanced picture (quality of life indices) of the possible futures.

*Alternative four.* Manage and control our use of resources on a carrying capacity basis. This could be a steady state scenario under alternative three. The carrying capacity alternative appears to have considerable potential for identifying sustainable balances between ecology and the economy. It is a new approach. In contrast, the other three approaches are either in use or being explored by others.

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Carrying capacity analysis provides a means of identifying alternative goals for population and economic growth, quality of life and quality of the environment. It is based on the assumption that uncontrolled growth of the population and economy of a region cannot be sustained forever.

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## *Carrying Capacity Analysis of the Pacific Northwest*

The remainder of this paper presents, within the limits of available information, the basic features of a prototype system for identifying different combinations of population levels, economic activity levels, and intangible value levels that are possible for the Pacific Northwest—an approach that identifies both the limits of basic natural resources of a region to support

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future growth and the desirable and undesirable consequences of various levels of growth.

Carrying capacity is an ancient principle in man's relationship to the land. It is an established method in the management of renewable resources such as agricultural land, forests, watersheds, and wildlife, but has not previously been applied to the entire economy and environment of a region. It was the way of life for mankind prior to the industrial and technological age beginning in the early 1800's—the age when man began the exponential exploitation of non-renewable resources. It represents capacity under a steady state or equilibrium conditions with only moderate oscillations in population but with continuous invention to increase choices and provide greater diversity.

It has been established that most, if not all, species of wild animals have instincts which usually tend to prevent overcrowding in their native habitat. They frequently thrive best at less than the maximum density which would be possible with the available food and shelter, etc. In other words, sustained carrying capacity estimates for different species of wildlife must recognize population density in addition to other constraints. There is growing evidence, but no conclusive proof and no consensus among experts, that similar principles apply to human society. Congested sections of some of our urban centers, for example, are experiencing social unrest and appear too crowded. There is growing evidence that there is a basic human need for natural open space and there may be an optimum population and acreage for individual urban areas. The carrying capacity in visitor days is being determined for parks, golf courses, hunting and fishing areas, wilderness areas, and similar recreation lands.

In the Pacific Northwest, both the bulk of the basic industries and the high quality scenery and outdoor amenities are dependent upon renewable natural resources—forests and grassland, mountains and valleys, rivers and lakes, agricultural land, urban and industrial land, seaports, ample high quality water, hydroelectric power sites,a continuous influx of clean air off the Pacific Ocean and good climate. Industries based upon location, such as those manufacturing transportation or electronic equipment or metals from imported ones, find the Northwest a desirable location because of its renewable natural resources. The secondary industries, which are generated by the basic industries, are similarly oriented.

The only basic Northwest industry which the study considers to be based primarily upon non-renewable resources is mining. But the Northwest supply of its most important minerals such as stone, limestone, phosphate, copper, lead, zinc, and nickel should last from 50 years to indefinitely. The Northwest presently is not self-sufficient in several vital minerals such as oil and gas, iron or aliminum ore. But this is no more of a disadvantage to the Northwest than it is to other mineral short regions of the nation.

With such a preponderance of the economy and the livability of the Northwest based upon renewable natural resources now and for the foreseeable future, would it be possible and desirable to determine carrying capacity for the Northwest in terms of population and production of goods and services per year (gross product)? Such an undertaking would require defining benchmark optimum needs in terms of gross product per capita as well as intangibles per capita. Such an approach does offer promise as a way to achieve a "balance of nature" under the spaceship earth concept. It offers promise as an alternate to the historical trend technique. It might avoid some of the pitfalls and uncertainties of long range forecasting.

## Methodology for Carrying Capacity Analysis

There are several techniques, very sophisticated, that might be used to apply the carrying capacity concept. This initial study attempts to concentrate on the major principles and critical factors, present them in a direct skeletal fashion, and illustrate the concept in the Pacific Northwest with first approximation numbers. The procedure is summarized as follows:

1. Determine benchmark standards for measuring Quality of Life. Average per capita income will be chosen as the parameter; an optimum apportionment of income among material necessities and intangibles, based on social theory, will be identified.

2. Assess the Gross Regional Product (GRP) and the amount of pollution in the base year (1965). Then determine the relationship between additional GRP and pollution with different levels of pollution control. Also assess potential constraints.

3. Assess the utilization of natural resources in the base year (1965) for GRP and for intangible purposes and their potential for the future on a carrying capacity basis. Assess potential constraints.

4. Within carrying capacity constraints identify the optional goals available for future growth in the Pacific Northwest in terms of various combinations of population and per capita GRP. Determine the relationship of each combination to (a) overall pollution levels in 1965, and (b) the quality of life benchmarks.

## A Quality of Life Benchmark

The first step in the process of applying carrying capacity analysis to identifying alternative "acceptable" long range goals for a region is to determine the various combinations of economic affluence and environmental quality that are attainable and how close these would be to the "optimum." In other words a technique is needed to measure the trade-offs between material quantity and intangible quality. There is no universal agreement concerning what would constitute an optimum quality of life in a particular geographic area for humans. To a degree, such perceptions are culturally oriented. However, probably a majority in the United States would agree that in an ideal environment the basic needs of every citizen would be satisfied and he or she would have full opportunity for personal fulfillment and have the assurance that his or her children and grandchildren, ad infinitum, would have the same opportunities.

Personal fulfillment ordinarily means reasonable opportunity to develop one's innate potential for creativity and constructive effort for the long term benefit of both himself or herself and society as a whole. In an optimum environment there would be ample challenge, diversity, and inspiration to satisfy a wide range of interests. There would also be moderate stress and competition—not an effortless society on the one hand or a ruthless, overdemanding one on the other. Every human would be needed, and respected as an individual. Everyone would have personal freedom and freedom of choice to pursue his own goals, whether they be economic, moral, social, or aesthetic. There would be ample opportunity for a wide variety of cultures and life styles. No one would be forced to reside where he either suffered from lack of human companionship or felt hemmed in by too many people.

There has been little scientific effort devoted to systematically identifying the elements that comprise an optimum quality of life. Yet if the people are to guide their future destiny, the ultimate goals must be described in both comprehensive and understandable terms. One way to come to grips with such a complicated problem, in the absence of adequate information about all its aspects, is to propose a basic conceptual framework and subject it to review, revision, improvement, and refinement. This description of a quality of life benchmark represents such a pioneering effort. It is needed as a reference point for measuring the quantity-quality trade-offs. Both the material elements and the intangible elements are essential to the realization of the desired quality of life, but one of the greatest potential threats this nation faces is that the intangible values will be irretrievably destroyed during the pursuit of short term material values. Indeed, the tragic evidence of such myopia is already apparent in too many parts of this nation.

To better their quality of life the people of nations throughout the world historically have placed initial emphasis upon acquiring the basic necessities. Frequently this required sufficient concentrations of population, and knowledge of science and technology to make more efficient use of available energy, automation, and mass production. Similar economies of scale usually have been necessary to maintain adequate facilities for security, education, health, government, and entertainment.

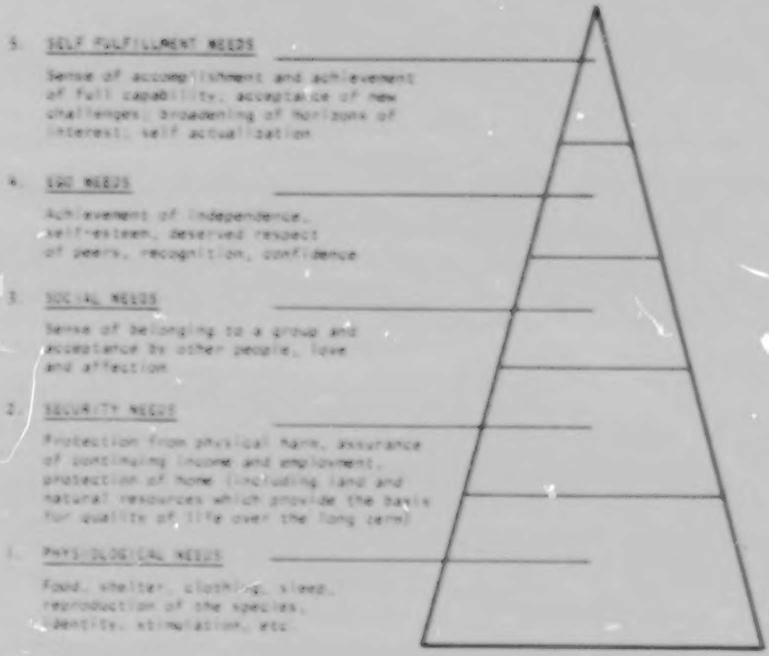
As soon as per capita income exceeds the amount needed to satisfy the most essential portions of basic and immediate material needs for existence such as food, clothing, housing, security, health, and transportation, the average person's (and nation's) interest and emphasis shifts to longer range and more intangible items (and our most perishable amenities) such as education, recreation, clean air, clean water, quietness, open space, personal elbow room, variety, and stimulation, cultural opportunities, attractive design and landscaping, natural scenic beauty and wilderness. Usually such amenities require a substantial number of servant machines per capita, including those used to control the adverse effects of production. Because of the increasing affluence and rising expectations of the average person, it appears that in the next century there will be sharply increasing interest in cultural and aesthetic pursuits and other quality aspects of the environment in the United States—an interest that was very low key during the past century—all concentrating on a land, water, and air resource base that is finite.

Other nations are similarly motivated. Those struggling for an economic toehold have little energy left for planning long range improvements; or as John Galbraith expresses it, "The natural priorities of a society proceed from getting the goods to getting the surroundings in which they can be enjoyed" (16). The United States now has the economic capability to invest heavily in measures designed to enhance the well-being of future generations.

## The Hierarchy of Human Needs as a QOL Rationale

Psychologists who have been studying human motivation in the United States refer to the relationship as the "*hierarchy of human needs.*" Those needs are depicted as a triangle consisting of five compartments with physiological needs at the base and self-fulfillment needs at the apex. The arrangement indicates that a need at one level tends to be the primary motivation after the most essential, but not necessarily all, of the needs at the lower levels have been satisfied (Figure 5). There are many individual exceptions, and the need categories tend to blend and intermingle. However, on the average, after the physiological and security needs are satisfied, energy is available for satisfying more intangible needs, assisting others and providing for future generations. Of course, without the necessary motivation, it may not be used for such purposes.

The hierarchy theory is that with each step upward (or downward) a person's, or a nation's, short range goals and priorities change. The long range hazard that some can clearly foresee, and others do not yet perceive, is that a nation's efforts to satisfy the basic material needs for an ever increasing population can foreclose the opportunities for eventually satisfying the intangible self-fulfillment needs essential for an optimum quality of life.



5. SELF FULFILLMENT NEEDS

Sense of accomplishment and achievement of full capability, acceptance of new challenges, broadening of horizons of interest, self actualization

4. EGO NEEDS

Achievement of independence, self-esteem, deserved respect of peers, recognition, confidence

3. SOCIAL NEEDS

Sense of belonging to a group and acceptance by other people, love and affection

2. SECURITY NEEDS

Protection from physical harm, assurance of continuing income and employment, protection of home (including land and natural resources which provide the basis for quality of life over the long term)

1. PHYSIOLOGICAL NEEDS

Food, shelter, clothing, sleep, reproduction of the species, identity, stimulation, etc.

Figure 5. The Hierarchy of Human Needs (17)

The hierarchy of needs theory may be useful as an illustration but the reader should be aware that it has limitations: it is not universally accepted. Also the emphasis on the various steps varies with different cultures between nations and within an individual nation.

## Marginal Utility as a QOL Rationale

As a supplement, and for those who have reservations about using the "hierarchy of needs" as an illustration, the "marginal utility" approach is presented also. As Seckler and Barkley explain it (13):

> In the developed countries goods and services have accumulated in upper middle class homes to such an extent that the marginal utility of "things" has surely dropped. At the same time, fresh air, clean water, wilderness and quiet (things often called "amenities") have one by one become more scarce, more dear".

The curves in Figure 6 show the decreasing marginal utility (MU) of goods over time and the increasing marginal utility of amenities over time.

Under such conditions the wisdom of producing more and more goods should be questioned since, by moving into the future (past time period P in Figure 6) the added utility of goods and services would be lower than the marginal utility of the amenities that had to be sacrificed in order to produce the goods. At point P', amenities with marginal values of OD have been sacrificed to obtain goods with marginal utility of OA. The difference (BC) indicates the net loss.

On the other hand, if the production of goods and services should level off, the marginal utility of amenities would tend to level off also.

## Per Capita Income as the QOL Standard

In order to satisfy all levels of human needs, financial resources are necessary. A generally understood and readily available common denominator for setting forth the specific elements which contribute to quality of life is an apportionment of average per capita income. Despite its deficiencies, money is a remarkably reliable and versatile measure of human reaction.

Therefore, with the concepts of the hierarchy of human needs and marginal utility of goods and amenities as background and supporting philosophies, we have chosen per capita income as the parameter for measuring quality of life. The assumption is that when a sufficiently high income is attained, quality of life, based on individual taste and philosophy can be attained by the members of society.

After a brief study of benchmark quality of life standards for 15 different categories of living expenses, an average per capita annual income of $7,500 in constant 1965 dollars ($30,000 gross for a family of four) is used

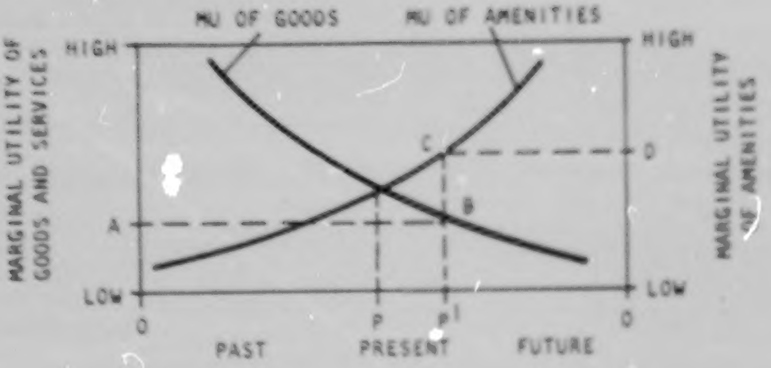


Figure 6. Marginal Utility of Goods and Amenities

to represent the amount needed to satisfy benchmark quality of life standards now or in the foreseeable future. This would be comparable to adopting the 1972 upper middle income standards as an average. No major change in income distribution is assumed. Individual incomes are expected to vary substantially from the $7,500 average, comparable to variations from the average in 1972.

The uses to which income is put are perhaps as important as the absolute level of income. A preliminary standard for apportionment of income to achieve a benchmark quality of life is shown in Table 2. The apportionment is related to the hierarchy of human needs in Table 3.

Our preliminary estimate is that about 28 percent of the $7,500 would be for physiological needs, 21 percent for security needs, 18 percent for social needs, 15 percent for ego needs, and 18 percent for self-fulfillment needs. The benchmark standards are pioneering examples. This apportionment is not based upon exhaustive or conclusive analysis; no such detailed studies are available (18).

In contrast, the Office of Business Economics Research Service, U.S. Department of Commerce (OBERS) projects that the $7,500 average will be reached about the year 2000 and advance to $13,200 by the year 2020. The $7,500 in per capita income compares to about $9,500 in per capita share of gross regional product. The latter is about 2.7 times the national average in 1967. It appears attainable only by increasing the productive efficiency or output of the average worker by 170 percent above the 1967 level. This would require major improvements in science and technology and continued availability of energy at acceptable prices. It would require an increase in servant machines per person from 13 in 1965 to 37. The per capita income in the Pacific Northwest is now, and is assumed to continue, at approximately the same level as for the remainder of the United States.

The per capita income of $7,500 and its apportionment, will be taken as the benchmark for quality of life standard. As the analysis proceeds, the income achievable under various combinations of population and economic growth will be used to assess the acceptability of each set of conditions.

### Capacity for GRP as a Function of Pollution Control

In 1965, our data base year, the Pacific Northwest GRP was about $20.5 billion but the average annual per capita income ($2,785) was only 37% of the benchmark standard. There was localized air pollution, water pollution, visual pollution, and land misuse. However, for the Northwest as a whole, natural systems were assimilating practically all of the waste produced. The Northwest was relatively uncongested and its high quality natural environment was largely intact.

Table 2. Average Apportionment of Income to Achieve Benchmark Quality of Life

| Expenditure Category | Average Per Capita for Member of Family of 4 in 1960 (Note 1) | | Average Per Capita Under Benchmark Standards, in 1965 $ | |
|---|---|---|---|---|
| | Dollars | Percentage | Dollars Required | Percentages of $7,500 |
| 1. Food | $ 400 | 18.33 | $ 960 | 12.8 |
| 2. Clothing | 138 | 6.30 | 450 | 6.0 |
| 3. Housing | 437 | 19.93 | 1,200 | 16.0 |
| 4. Transportation | 290 | 13.20 | 700 | 9.34 |
| 5. Health | 235 | 10.74 | 320 | 4.26 |
| 6. Education | 149 | 6.81 | 380 | 5.07 |
| 7. Clean Air | - | (Note 2) | 150 | 2.0 |
| 8. Clean Water | - | (Note 2) | 160 | 2.13 |
| 9. Solid Waste Disposal | - | (Note 2) | 110 | 1.47 |
| 10. Quiet | - | (Note 2) | 160 | 2.13 |
| 11. Attractive Surroundings | - | (Note 2) | 130 | 1.73 |
| 12. Recreation | 72 | 3.31 | 400 | 5.33 |
| 13. Open Space | - | (Note 2) | 320 | 4.26 |
| 14. Savings, Contributions, Insurance, and Misc. | 164 | 7.48 | 560 | 7.46 |
| 15. Federal, State, and Local Government (Note 3) | 305 | 13.90 | 1,500 | 20.0 |
| Total | $2,192 | 100% | $7,500 (Note 4) | 100% |

NOTE 1: U.S. Department of Labor, Bureau of Labor Statistics, Survey of Consumer Expenditures, Western Region.

NOTE 2: Not segregated by BLS in 1960--probably included under other items.

NOTE 3: Includes government expenditures for items other than the 14 categories listed in Table 4. Government expenditures assumed to be 60% Federal, 20% State, 20% Local. Information concerning government expenditures from the Federal Budget--1960, and State of Washington, Office of Program Planning and Fiscal Management.

NOTE 4: Equivalent to $9,500 in per capita share of gross product.

Table 3 Relationship Between the "Hierarchy of Human Needs" and "Average Apportionment of Income Benchmark Quality of Life

MEANS TO SATISFY NEEDS (AVERAGE ANNUAL PER CAPITA BUDGET)

| HUMAN NEEDS | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | TOTALS |
| 1. PHYSIOLOGICAL | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | | [illegible] |
| 2. SECURITY | [illegible] | | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | [illegible] | [illegible] | | | [illegible] | | [illegible] | [illegible] |
| 3. SOCIAL | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 4. EGO | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 5. SELF-FULFILLMENT | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 6. TOTALS | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

Figures used represent preliminary subjective estimates of the principal author.

As used in this study, the term pollution includes all kinds of activities by man which cause land spoilation, water quality degradation, air quality degradation, or harmful noise.

The adverse effects of pollution can, within limits, be mitigated by increasing pollution control. Techniques for pollution control include: (1) redesigning processes, machines, etc., to reduce pollution at its source; (2) shift of emphasis to goods and services with inherently less pollution problems (changing the composition of the GRP); (3) cleaning up effluents and emissions before releasing them; (4) recycling wastes; and (5) deliberately planning and implementing all development so that it is in harmony with natural ecosystems.

### Estimated Artificial Pollution Control in 1965

The exact amount of articifical pollution control in the Pacific Northwest in 1965 is unknown. A rough estimate of the amount of recycling (mostly solid wastes) is 10%. Other forms of artificial pollution control did exist (primary and secondary sewage treatment plants and rudimentary erosion control are two examples), but there was almost no control of noise or of emissions to the atmosphere. The total artificial pollution control, in addition to recycling, was perhaps between 5 and 10%. Let us assume 7%, making the total 17%. The exact amount is not critical; it could vary 5% + or - without a significant effect upon the end results.

### Estimated Natural Capacity to Assimilate Waste

In addition to artificial pollution control, we must account for the capacity of natural systems to assimilate waste. The capacity of natural systems must not be exceeded if the benchmark quality of life standards are to be met. In the Pacific Northwest in 1965 there was localized air pollution, water pollution, land abuse, visual pollution, and solid waste problems, for example. This indicated that the assimilative capacity of the natural systems had been exceeded locally. In many other cases, however, it appeared that the natural systems had additional pollution absorption capacity. If the pollution in 1965 had been distributed more widely it might have been absorbed by the natural systems without degradation. This is probably on the optimistic side and is debatable. However, for purposes of this study let us make such an assumption. That assumption would mean that, on a regional average basis, the combined capacity of the natural and the artificial systems was adequate to handle the total pollution load in 1965.

### Technological Limitations to Achievable Pollution Control

A goal of either 100% artificial pollution control or zero waste per unit of GRP is unattainable from both the technological and economic standpoints. The cost and technical difficulty of reducing, by artificial means, the amount of pollution from a given source increase rapidly as zero pollution is approached. The absolute limit is reached when the pollution created by the clean-up servant machines is as great as the improvement in pollution levels. There has been no overall assessment of what this limit on reduction of pollution may be. There is only limited information for individual component industries. The best we can do is to assume a limit based upon present partial information and revise it as more complete information becomes available. Our assumption is that technological constraints limit pollution control to 90%.

### Economic Limitations to Achievable Pollution Control

The benefits (both material and intangible) resulting from additional investments for pollution control must exceed the costs. But here the law of diminishing returns becomes increasingly important as the 90% physical limit is approached.

Unfortunately, there is, at present, no reliable overall assessment of what the upper economic limits may be. Possibly they lie between 80% to 90%. Let us make the optimistic assumption of 90% and revise it in the future as more information becomes available.

### Assumed Maximum Achievable Pollution Control

Combining the 90% technological limit and the 90% economic limit, the maximum achievable pollution control will be assumed to be 90% x 90% = 80% (rounded). Attainment of the 80% would require a substantially increased application of (a) science and technology, (b) natural resource management, and (c) land use controls. This is clearly beyond the scope of such measures in effect or seriously contemplated anywhere in the nation in 1972 (19).

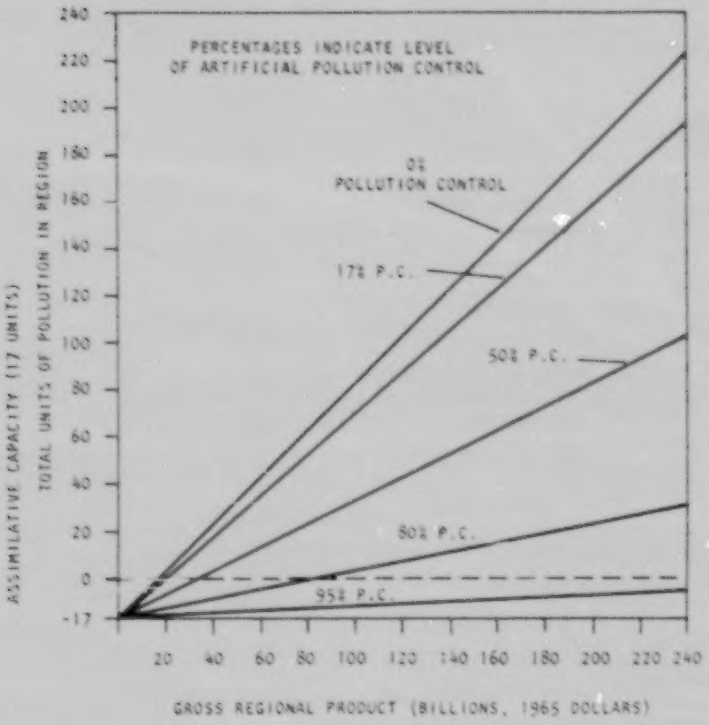
### Definition of Pollution Unit

For discussion purposes, we will define one pollution unit as that produced by $1 billion in GRP, with no artificial or natural pollution control. This definition provides a convenient way of relating pollution to GRP and permits a first approximate way of studying the effects of pollution control.

With this definition the number of pollution units produced by a region is (GRP in billions of 1965 dollars) x (100%-% of pollution control)/(100). For example, a region with $100 billion GRP and 20% pollution control would produce (100) x (100-20)/100 = 80 units.

The relationships for five levels of pollution control are shown in Figure 7. The following can be seen from the Figure.

1. With 80% pollution control, the GRP cannot exceed $85 billion if the objective is to maintain pollution at the assimilative capacity of natural systems (1965 level).



This assumes that no units of pollution occur until the pollution assimilative capacity of natural systems is reached and that after that point one unit of pollution is equivalent to $1 billion in gross regional product. The GRP in 1965 was $20.5 billion with 17% pollution control. Total pollution produced was 20.5 x (1.00-0.17) or 17 units. It is assumed that these units represented the full assimilative capacity of natural systems with the results that there were zero net units of pollution in 1965. (3.5 units were controlled artificially.)

igure 7. Units of Pollution With Alternative Combinations of GRP and ollution Control

2. If the pollution standard is relaxed to permit 51 units (3 times the 1965 level) the GRP could be $340 billion, with 85% pollution control.

3. If only 17% pollution control is achieved, $340 billion in GRP would produce a net 282 pollution units in the region.

4. The $208 billion GRP projected forecast by OBERS for the year 2020, given the 80% maximum pollution control, will produce 42 pollution units, 25 units above the 1965 level or about 1½ times the assumed natural assimilative capacity of the region.

These examples should not be taken as firm conclusions. They serve only to illustrate the technique we have chosen for assessing relative levels of pollution resulting from alternative combinations of pollution control and GRP.

### Capacity for Sustained Use of Natural Resources for Material Purposes

The second major step in applying carrying capacity analysis is to determine the capacity of the region for sustained use of natural resources for material purposes, i.e. generating GRP.

An approximation of the long term carrying capacity of the Pacific Northwest as a whole for both population and gross product may be made by analyzing its available land and its natural and man made resources. This approximation includes the assumption that the relatively good quantity and quality of Northwest capital, management, and labor would continue. It assumes that inter-regional and international trade will increase, limited however by the capacity of Northwest natural resources to provide the base for such trade on a sustained basis. It is also based upon the proposition that although major future breakthroughs in science and technology are possible, they are by no means assured. The first priority should be a major re-orientation of science and technology to correct the backlog of problems caused by economic growth such as ecosystem disruption, poisons, eutrophication, soil erosion, maldistribution of population, excessive noise, and all manner of emissions and effluents. A prudent procedure is to base assessments of sustainable future economic activity upon today's knowledge. Changes in those assessments are warranted only after breakthroughs in science and technology actually occur and are proven to be a positive step in the direction of an optimum quality of life.

### Methodology for Determining Capacity

The capacity of the Pacific Northwest was estimated by cataloging the available renewable and non-renewable natural resources and estimating the goods and services which could be produced by primary and secondary industries. A full discussion of the technique is presented in Appendix 6 of Reference 18.

To illustrate the procedure a summary of the analysis of the commercial forest land is presented here. For comparison purposes it is necessary to determine the capacity production in the base year, 1965. The Census of Manufacturers published by the Bureau of Census estimated that lumber, wood, paper and allied products contributed $1,936 million to the regional GRP in 1967. Comparable figures are not available for 1965, however, assuming the production was 15% less, the 1965 production was taken as $1,670 million.

Research revealed that the production volume could increase by a factor of 1.6 assuming full stocking, full utilization and all other measures to take advantage of full soil productivity on all available acreage.

In addition to increased forest production the local manufacturing could also increase by a factor of 1.25. Together these factors yield a potential increase by a factor of 2, thus resulting in an estimated capacity for the commercial forest land of $3,340 million annually.

### Results of Analysis

Using similar forecasting techniques the results shown in Table 4 were obtained. Some preliminary conclusions can be drawn, relating the capacity for GRP to pollution levels (refer to Figure 7):

1. With 80% pollution control, the region can sustain only $85 billion GRP without raising pollution above the 1965 level. The tentative $116 billion exceeds that limit by 36.5%.

2. If the GRP reaches $116 billion the pollution will rise to 23 units (1.4 times 1965 levels) with 80% pollution control or to 57 units (3.3 times 1965 levels) with 51% pollution control.

Given the desire of the population to maintain pollution at or near the 1965 level, it is clear that effective pollution control must be planned now whatever growth is experienced in the next decades. It is also clear that the region might consider means of keeping growth below the estimated capacity of $116 billion.

However, a factor of greater potential concern is the availability and cost of energy to fuel an increase in GRP. This study assumes that energy will not be a limiting factor for Northwest growth in relation to other regions of the United States. However, there is growing evidence that increasing costs and decreasing availability of energy sources and environmental problems associated with energy may sooner or later limit economic growth of the nation as a whole.

The $116 billion GRP for the Northwest would be over $5^{1}/_{2}$ times the level in 1965 and would require about $5^{1}/_{2}$ times the use of energy (20). Probably electrical energy will comprise an increasingly larger share of the total energy needs than was the case in 1970. At that time the total energy

Table 4. Estimated Potential of Pacific Northwest Resources to Produce Continuous Gross Regional Product (Millions of 1965 dollars, rounded)

| Resource Use For Material Purposes | Production, 1965 | Sustained Production Potential |
|---|---|---|
| Basic | | |
| Commercial Forest Land | $ 1,670 | $ 3,340 |
| Agricultural Land | 1,560 | 8,740 |
| Commercial Fisheries | 70 | 120 |
| Recreation and Tourism | 900 | 6,000 |
| Industry Based Upon Location | 2,860 | 8,580 |
| Mining and Minerals | 620 | 2,150 |
| Subtotal | $ 7,680 | $ 28,930 |
| Ancillary | | |
| Secondary Industries | 12,770 | 86,890 |
| Totals | $20,450 | $115,720 |

used in the Pacific Northwest consisted of 43% electricity and 57% other forms. Electrical energy is a convenient method for converting both falling water and various kinds of fuel into energy needed to power machines. Most authorities agree that, if equipped with the best available air pollution control devices, even fossil fuel electric generating plants produce far less air pollution than burning an equivalent amount of fossil fuel in individual motors. Under optimum conditions electricity would provide perhaps 75% of the total energy needs for the Northwest or nearly seven times the 1965 level of use of electricity, assuming combination 4b in Table 6 (21). Fusion, solar (including sea-thermal), and geothermal generating plants may eventually prove to be both feasible and relatively pollution free. Also, electrical energy can be used to produce by electrolysis an excellent pollution free portable fuel, hydrogen (22).

## Capacity for Sustained Use of Resources For Intangible Purposes

Intangible benefits to the individual from both the natural and the man-made environment include all manner of physical and mental well-being, peace of mind, exhilaration, aesthetic satisfaction, comprehension of man's relationship with other parts of the natural and man-made world and other factors not readily nor necessarily equatable with the material rewards that flow from the exploitation of natural resources. Wild areas are part of man's past and essential to his welfare. The biological rhythms of modern man, which shape his life, are often tied to the natural forces beyond his urban surroundings (23).

### Methodology for Estimating Capacity

The best available common denominator for measuring the uses for intangible purposes appears to be the recreation land classes originally recommended by the Outdoor Recreation Resources Review Commission in 1961 and adopted by the Bureau of Outdoor Recreation (BOR) in 1964. Despite a lack of detail in the BOR classification system about urban and multiple use categories of recreation land and deficiencies in BOR's first national inventory, it does provide an acceptable framework for a beginning. The results of applying this technique to carrying capacity for intangible purposes is shown in Table 5.

One purpose of the BOR system, as well as other similar systems and standards, is to help measure otherwise imponderable needs. The basic structure of the BOR system appears sound, but since the needs and carrying capacities to be measured are mostly intangible, some of the results summarized in Table 5 necessarily are subjective.

The acreage of dedicated and potentially available recreation land in each of six land classes and three sub-classes is determined. The carrying

Table 5 Estimated Potential of Pacific Northwest Land and Resources to Yield Intangible Uses Needed for "Optimum" Availability

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|
| | Total Acres 1965 (1,000's) | | | | Annual Carrying[1/] Capacity of Dedicated Lands in Visits | | [Annual Capacity Needed for Optimum - 19[illegible]5] | |
| BOR Recreation Class | Dedicated | Additional Available | Available | Totals | Per Acre | 1965 Total (Millions) | Visits Per Capita | Million visits for 5.8 Million |
| I. Urban | 20 | Probably[4/] Over 150 | 0 | 20 | 3,000 | 60 | 100 | 580 |
| II. Rural Sites | 913 | Nearly [4/] Unlimited | 0 | 913 | 250 | 228 | 4 | 23 |
| III. Multiple Use (Except a & b) | 76,719 | 59,128 | 21,675 | 157,522 | 1 | 77 | 12 | 70 |
| a. Wildlife Areas | | | | | | | | |
| 1. Hunting & Observation | Existing [5/] Habitat Public Lands | Existing [5/] Habitat Private Lands | [4/] | | 2 | 15 | 4 | 23 |
| 2. Fishing | Existing [5/] Habitat Public Lands | Existing [5/] Habitat Private Lands | [4/] | | 20 | 23 | 4 | 23 |
| b. Free Flowing [8/] River Corridors (1970) | 826 (2,580 miles) | 2,422 (7,570 miles) | 0 | 1,248 (10,150 miles) | 12.5 | 10 | 2 | 12 |
| IV. Outstanding Natural Areas | 2,935 | 0 | 0 | 2,935 | 25 | 73 | 6 | 35 |
| V. Wilderness [9/] | 6,340 | 2,694 | 0 | 9,034 | 0.5 | 3 | 0.3 | 2 |
| VI. Historic and Cultural Sites | 43 | [4/] | [4/] | 43 | 3,000 | 129 | 2 | 12 |
| TOTALS | 87,796 | 64,244 | 21,675 | 173,715 | | 618 | 134.3 | 780 |

Table 5 (Continued)

| (1) | (10) Surplus(s) or 2/ Deficit(d) of Dedicated Areas In 1965 | (11) | (12) Additional 3/ Dedicated Acres Needed Per Million Population Increase After 1965 (1,000's) | (13) Dedicated Acreage Needed In addition to 1965 Base (1,000's) | (14) | (15) |
|---|---|---|---|---|---|---|
| BOR Recreation Class | Capacity In Visits (Millions) | Acres (1,000's) | | For 10 Million Residents | For Assumed Non-Resident Use | Totals |
| I. Urban | 513(d) | 171(d) | 33 | 310 | 7 | 317 |
| II. Rural Sites | 205(s) | 820(s) | 16 | None | None (50%) | None |
| III. Multiple Use (Except a & b) | 7(s) | 7,119(s) | 12,000 | 43,281 | 12,000 (10%) | 55,281 |
| a. Wildlife Areas | | | | | | |
| 1. Hunting & Observation | 8(d) | 4,000(d) | 2,000 6/ | 12,400 6/ | 1,000 (5%) | 13,400 |
| 2. Fishing | 0 | 0 | 200 6/ | 840 6/ | 400 (20%) | 1,440 7/ |
| b. Free Flowing 8/ River Corridors (1970) | 2(d) | 102(d)<br>(320 mi.) | 160<br>(500 mi.) | 774<br>(2,420 mi.) | 1,200 (75%)<br>(3,750 mi.) | 1,974<br>(6,170 mi.) |
| IV. Outstanding Natural Areas | 38(s) | 1,520(s) | 240 | None | 65 (25%) | 65 |
| V. Wilderness 9/ | 1(s) | 2,860(s) | 600 | None | 2,660 (50%) | 2,660 |
| VI. Historic and Cultural Sites | 117(s) | 39(s) | 0.7 | None | None | None |
| TOTALS | 155(d) | 8,085(s) | 15,249.7 | 57,605 | 17,342 | 75,147 |

capacity in recreation visits per acre per year for each class and sub-class is indicated. Also an estimate is made of the number of annual visits an average resident would make to each class of land per year under "optimum" conditions. A percentage of non-resident use for each recreation land class is assumed.

The benchmark optimums selected are based upon personal judgment. *They are not supported by authoritative research reports* because such research has not been conducted. *Hence, the benchmark use figures should be considered as temporary* until adequate studies are completed and more reliable information becomes available. Also, it is emphasized that the number of visits are assumed optimums, not forecasts or historical trend projections.

Additional discussion of the standards and rational used in estimating carrying capacity for intangible purpose is found in Appendix 6 of Reference 18.

## Results of Analysis

It is evident that the most critical intangibles that would limit future population growth are located mostly on the 60% of Pacific Northwest land which is in public ownership. These values are wildlife areas, wilderness areas, outstanding natural areas, and wild and scenic rivers. The present supplies of these resources cannot be expanded. They are all that will ever be available. However, some of the areas, particularly those used by wildlife, could be improved or better managed.

In 1970 there was insufficient acreage of land dedicated to any of the above four purposes to serve the benchmark "optimum" needs of a resident population of 10 million plus an assumed percentage of use by non-residents. However, if all or most of the lands that qualified were also dedicated there would be sufficient. But much of the otherwise qualified acreage would not be ideally located since it lies in portions of the region the farthest from population centers.

Presently, as compared to optimum conditions, there is a large deficiency of land in Northwest urban areas devoted to recreation and open space purposes. Sufficient open land is available which could be dedicated to such purposes for present urban centers, also new urban centers could be created with ample dedicated open space from the inception. Theoretically, the availability of urban recreation and open land should not place a constraint upon future Northwest growth. However, very poor performance in both preserving and developing public use areas in urban centers in the past and the difficulty in insuring adequate funds, authority and integrity of long range planning, give little reason for optimism.

A truly farsighted approach to long range planning avoids irrevocable commitments now on all the land and resources. It leaves a significant percentage undeveloped so that future generations can exercise their own options in light of future conditions—conditions that we presently cannot foresee.

In summary, using the standards employed in this study, land and resources of thePacificNorthwest, if managed according to sufficiently comprehensive and farsighted planning, are adequate to permit "optimum" use for intangible purposes by 10 million residents, plus about 25% use by non-residents. Population growth beyond that point probably would be at the expense of "optimum" livability for the average resident. The most fragile areas, such as wilderness and wild rivers, would be the first to be overused (or use denied).

Of course sacrifice of some of the "optimum" amenities would leave a type of environment "acceptable" to many people. However, once living conditions deteriorate below the optimum, the difficulty of regaining the optimum probably would increase exponentially as compared to the arithmetic rate of decline (24). Extreme and arbitrary controls would be necessary—a totalitarian type government. Obviously it is far easier, and more compatible with the almost universal desire for personal freedom, diversity, and for multiple choices, to keep population and industry levels that permit the optimum use of the limited supply of resources which yield intangible values than it is to allow excessive growth, then attempt to remove some of that growth and restore intangible values in order to gain optimum livability.

## Summary of Carrying Capacity Analysis

The principal assumptions and results of the analysis are summarized as follows:

1. A per capita share of annual GRP equal to $9500 is required to attain the benchmark quality of life standard. This is equivalent to $7500 annual per capita income, apportioned as shown in Tables 2 and 3.

2. Because of technological and economic limitations a maximum artificial pollution control of 80% is assumed attainable. Pollution in a region is calculated in pollution units as: GRP (1-PC)-(the pollution absorbed naturally). PC is the pollution control expressed as a decimal fraction. Thus in 1965, with a GRP of $20.5 billion, no pollution control and 17 pollution units absorbed naturally, there were 3.5 pollution units in the Pacific Northwest.

3. The capacity of the Pacific Northwest for GRP was estimated to be approximately $116 billion.

4. The capacity of the Pacific Northwest for intangible purposes was estimated at 10 million residents with 25% use of resources by non-residents.

5. The number of servant machines per capita is estimated as (share of GRP)/($250)-(1.0). Thus in 1965 with a per capita share of GRP equal to $3520 the number of servant machines per capita was equal to (3520)/(250)-1 = 13. It was also pointed out that as the number of servant machines increases the pollution they produce must be controlled. Another way of stating this is that the impact per servant machine must be no more than 1-PC.

6. Given the constraints, a) maximum pollution control achievable is 80% and b) pollution must be kept at 1965 level, then the GRP of the Pacific Northwest must not rise above $85 billion.

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## *Alternative Goals for the Pacific Northwest*

Within the constraint of the benchmark quality of life, there are many alternative goals for the Pacific Northwest. Some choices are summarized in Table 6.

Note that in 1965, with no artificial pollution control, the natural systems absorbed 17 pollution units and 3.5 units were not absorbed. It would require 17% artificial pollution control to reduce the region pollution to zero.

Cases number 1, 2, 3, 5 show conditions for pollution control at 2, 3, 4 and 5 times the 17% required for no pollution in 1965. In each case the GRP sustainable for no pollution is given. The a, b (and c in case 5) alternatives show the population sustainable for several alternative per capita share of GRP. Cases 5 and 6 present the same information for 80% (maximum achievable) and 95% pollution control. Obviously 95% control represents over-control if the GRP remains $116 billion.

For each case, the number of servant machines per capita and the required impact limitations of the servant machines is also given.

The apparent optimum set of conditions is given in case 4b. The population of 9 million is less than the capacity for intangible purposes, with a 10% margin. Per capita share of GRP equals our benchmark standard for quality of life, and each person has 37 servant machines. Technology would have to be developed to achieve 80% pollution control (and 20% servant machine impact).

Similar data, showing sustainable population as a function of share of GRP for several levels of pollution control are shown in Figure 8.

The carrying capacity estimates in this study are not "fixed for all time"; neither is the benchmark definition of quality of life, nor the 80% ceiling on reduction of adverse effects of production. As new knowledge, new methods of resource management, new technology, and better understanding of man's social and environmental needs are discovered,

Table 6 Estimated Capacity of Pacific Northwest Natural Resources to Support Population and Gross Regional Product With Different Percentages of Pollution Control

| Case No. | Population (Millions) | Per Capita Share GRP in 1965 $ | Percent of Pollution Control | Total GRP (Billion $) | Pollution Units in Region | Servant Machines Per Capita | |
|---|---|---|---|---|---|---|---|
| | | | | | | No. | % Impact Per Machine |
| 1965 Assuming no pollution control | 5.8 | $ 3,520 | 0 | $ 20.5 | 3.5 | 13 | 100% |
| 1965 with Pollution Control | 5.8 | 3,520 | 17 | 20.5 | 0 | 13 | 83 |
| 1a | 5.1 | 5,100 | 34 | 26 | 0 | 19 | 66 |
| b | 2.7 | 9,500 | 34 | | | 37 | 66 |
| 2a | 6.9 | 5,100 | 51 | 35 | 0 | 19 | 49 |
| b | 3.7 | 9,500 | 51 | | | 37 | 49 |
| 3a | 10.4 | 5,100 | 68 | 53 | 0 | 19 | 32 |
| b | 5.6 | 9,500 | 68 | | | 37 | 32 |
| 4a | 16.7 | 5,100 | 80 | 85 | 0 | 19 | 20 |
| b | 9.0 | 9,500 | 80 | | | 37 | 20 |
| 5a | 22.7 | 5,100 | 85 | 116 | 0 | 19 | 15 |
| b | 12.2 | 9,500 | 85 | | | 37 | 15 |
| c | 6.9 | 16,800 | 85 | | | 66 | 15 |
| 6a | 22.7 | 5,100 | 95 | 116 | -11 | 19 | 5 |
| b | 12.2 | 9,500 | 95 | | | 37 | 5 |
| c | 6.9 | 16,800 | 95 | | | 66 | 5 |

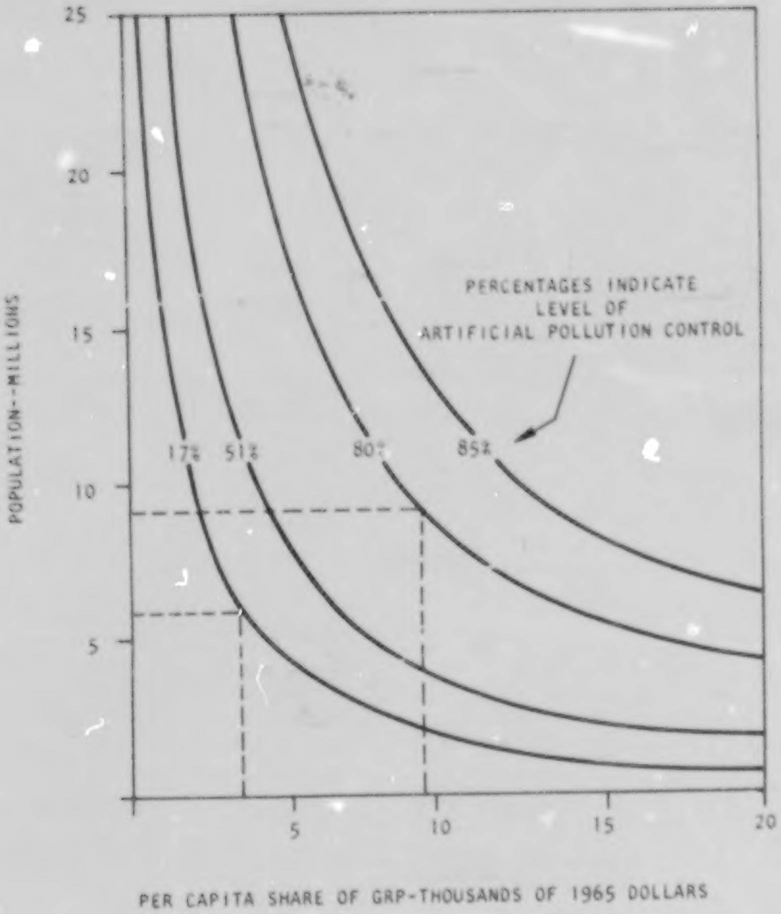

Figure 8. Carrying Capacity With Four Levels of Pollution Control

thoroughly tested and proven, adjustments should be made. For example, a percentage correction factor could be applied to the $250 per servant machine if actual experience demonstrates that the Pacific Northwest gross product mix in the future has a different adverse effect per servant machine than in 1965. However, the assumption should not be made that new knowledge will always make possible upper adjustments in growth of population and production. The opposite could occur.

## *Carrying Capacity Implications for Policy*

Although the carrying capacity concept is in its infancy and is untested as far as the population, economic activity, and intangibles (amenities) of a large geographic area is concerned it is not too early to speculate about the practical aspects of implementation. Peterson's recommendations for future goals, policy and implementation techniques are presented below.

### Incentives and Other Tools Available

Even a cursory examination reveals a number of means that are presently available to provide financial and other incentives and guidance for the desired direction and rate for population and industrial growth or no-growth within a region. The most obvious of these are listed below. These are proven techniques fully in accord with traditional democratic principles. Most of them have long been used in the United States to promote or accommodate growth and development. They are equally available to dampen or channel that growth but have not been used consistently for such a purpose. They would apply equally to both residents and potential new residents. Most of them could induce feedback in the market system that would slow or halt the more damaging kinds of growth. Obviously there are other techniques which would be undemocratic or unconstitutional (such as a quota system with gates at the borders). The techniques include:

1. Full public information and education about resources, population, pollution, and growth potential.
2. Legislation. (Example: land use planning and zoning, environmental policy, growth policy.)
3. Encouragement or discouragement of growth in population or industry in a specific region or locality, both urban and rural, by public officials. (Example: advertisements in national magazines.)
4. Organization of executive departments of government—Federal, state, and local. (Example: regional and multi-state associations of governments.)
5. Location and capacity of highways, waterways, airports, railroads, ports, and other transportation facilities.

6. Availability of credit for development projects.

7. Availability and cost of electric power and other forms of energy.

8. Availability, cost, and control of water supplies.

9. Financial and other incentives for new industries on the one hand or special charges or requirements on the other.

10. Urban and rural land use development controls such as subdivision and zoning regulations, and covenants in land titles.

11. Public acquisition or disposal of key tracts of land, and control of resource development, settlement and use of lands in public ownership.

12. Enactment and enforcement of anti-pollution laws and regulations and use of effluent and emission charges.

13. Regulation of land speculation and real estate promotion.

14. Tax policies.

15. Policies for providing public services such as schools, hospitals, communication facilities, waste disposal facilities, and welfare benefits.

16. Policies concerning family planning by residents.

Of the 16 possible tools listed above, the indispensible elements appear to be as a minimum (1) full public information, (2) a popular consensus of what the goals should be, and (3) effective land use and energy planning and controls.

The fact that proven tools are available does not mean that long range growth goals will magically evolve and the tools to implement them automatically be used for such purpose. A major and constantly increasing multi-pronged effort by influential persons and interests representing a cross section of our society would be essential.

**Need for Public Information**

To set a solid foundation for such a sustained effort we need, in the opinion of the author, to give first priority to full public information and education about resources, population, pollution, and growth potential. Also we must have a solid foundation of facts to support conclusions. In many instances such facts can be obtained only with more research and field tests, particularly interdisciplinary, and using synthesis and deductive techniques. The interrelationship between natural resources, science and technology, population, economic growth, and quality of life needs much more attention at all educational levels.

At all levels we need to replace the rhetoric and exaggeration of both the instant environmentalists and the reactionary addicts of exponential growth with solid facts.

**Needed Legislation and Reorganization**

In the legislative and organization area I think first priority should be a national land use policy act plus compatible state legislation.

Organizationally, in my opinion, we need Departments of Natural Resources, both nationally and at the state levels. These departments offer hope for much better coordination in our land use, energy, water, and air policies and programs. We also need effective organization for coordinated management of natural resources in multi-state regions, and at the state level, for multi-county regions.

At the national level there needs to be better coordination among all responsible agencies at all levels. We need reliable indices for environmental quality as well as for economic activity and for natural resource supply. (The latter provides the foundation for the other two.) We must be able to assess the consequences of increased activity in one category upon the other two and to measure the trade-offs.

Assuming that land use policy acts are enacted, Departments of Natural Resources created, and better correlation between environmental quality, economic activity, and natural resource supply attained, we will need a large number of qualified agents to help explain the situation at the grass roots level over a period of years. An example of a highly successful program of this type is the Cooperative Extension Service sponsored by the U.S. Department of Agriculture and the land grant universities. This service to farmers in the last 50 years has brought about a benevolent revolution in agricultural production in the United States. Couldn't a similar approach be equally beneficial in urban and rural land use and water and energy planning (including population and economic growth and environmental quality)? Do we need a national land and water resources council and subsidiary regional commissions?

### Needed Research and Methodology Development

Regardless of whether carrying capacity concepts are adopted nationally, regionally, by states, or not at all, it appears to me that new information and different ways of assimilating the information would be highly useful. Much of such effort may be considered in the category of research.

1. Economic activity, environmental quality, and natural resource supply indices should be on a par (receive equal emphasis) and be based on a common framework of data compilation, assumptions, methodology, and language so that one can be readily compared with the other two and accurate interrelationships and trade-offs determined. All official reports, statistics, etc., should reflect this common framework.

2. A common natural resource inventory data system used by all national, regional, state, and local planning and program agencies and private interests is needed as is a system for keeping it updated continuously.

3. There needs to be a standard definition of various categories and subcategories of pollutants.

4. A technique for determining capacity of natural systems to assimilate various categories of pollutants without degrading natural ecosystems needs to be perfected.

5. A system is needed for measuring the percentage of existing artificial pollution control by various categories and subcategories.

6. Accurate methods for determining the technological and economic upper limits for artificial control of various categories of pollutants are needed. Also some method for weighing the various categories to get an overall figure would be very useful.

7. A common system for monitoring all major types of pollutants and several subcategories is needed.

8. The relationships between natural resources and economic activity need considerable clarification. In particular the natural resources which support "industries based upon location" need attention. Also, the percentage relationships between "basic" and "secondary" industries and potential future changes has had inadequate study. All studies in this category should be multidisciplinary and not left as the exclusive province of economists.

9. The extent to which the carrying capacity of various renewable natural resources can be increased and the life of non-renewable resources extended by management intensity, science and technology, conservation, and recycling is a fertile field for research.

10. The carrying capacity of various categories of renewable natural resources in terms of human use and enjoyment needs to be determined.

11. A considerable effort should be devoted to studying "optimums" for the long range future in terms of per capita income (with various subcategories) and intangibles (with various subcategories).

## *Notes for Chapter 3*

1. Report of the Study of Critical Environmental Problems, "Man's Impact on the Global Environment", MIT Press, Cambridge, Mass., 1970.
2. Caldwell, L. K., "Environment: A Challenge to Modern Society", American Museum of Natural History, the National History Press, 1970.
3. It is emphasized that the "servant machine" is only a convenient illustration and is not a central issue in developing the carrying capacity concept.
4. *Business Week*, October 24, 1970. Also, "Economic Report of The President", 1971.
5. Gabor, Denis, "The Mature Society", Praeger, 1972.
6. Hardin, Garrett, "The Tragedy of the Commons," *Science*, Vol. 162, Dec. 13, 1968.
7. Committee on Resources and Man - Preston Cloud, Chairman, "Resources and Man," National Academy of Sciences, W. H. Freeman & Co., 1969.
8. SCEP (Report of Critical Environmental Problems), "Man's Impact on the Global Environment," sponsored by the Massachusetts Institute of Technology, MIT Press, 1970.
9. Ehrlich and Ehrlich, "Population, Resources, Environment," W. H. Freeman & Co., 1970.
10. Commoner, Barry, "The Closing Circle," Alfred Knopf, 1971.
11. Goldsmith, Edward, et al., "A Blueprint for Survival," *The Ecologist*, January, 1972.
12. "Commission on Population Growth and the American Future, Final Report" The New American Library, Inc., March, 1972.
13. Seckler, David W., & Barkley, Paul W., "Economic Growth and Environmental Decay," Harcourt Brace Jovanovich, Inc., 1972.
14. See Chapter VIII, *Population, Growth, and Resources* "The First Annual Report of the Council on Environmental Quality", August, 1970.
15. An example is the July 17, 1970, report to the President by the National Goals Research Staff entitled "Toward Balanced Growth: Quantity with Quality." Another example is the March 1970 report of the California Select Committee on Environmental Quality, which recommends an amendment to the State Constitution providing an "Environmental Bill of Rights." A third is a sketch version of a plan for the future of California to the year 2000 developed by the organization California Tomorrow, San Francisco, 1972.

As Professor Elbert Bowden* observes, "Once he ventures into the realm of concepts to which meaningful numerical values cannot be assigned, the regional economist loses the opportunity to apply much of his specialized methodology. He is stripped of his aura of mysticism and compelled to communicate with policy-makers and administrators in their own language. Suddenly he is faced with the need to demonstrate his understanding of the real world workings of a broad range of economic theory. It is easy to understand the desire to shy away from such demanding circumstances."

*Professor of Economics, State University of New York, Fredonia, in *Land Economics Journal*, May 1971.

16. Galbraith, John, "Economics and the Quality if Life," 5 *Science*, 1964.

17. McGregor, Douglas, "Leadership and Motivation," Massachusetts Institute of Technology Press, Cambridge, Mass. (1966), also Maslow, Abraham H., "Motivation and Personality," Harper & Row, New York (1954).

The area in the five compartments does not represent the importance or weight assigned to each. Only the most essential needs (not the ultimate needs) at one level must be satisfied before attention is devoted to needs at higher levels. The "most essential needs' in each category vary widely between individuals and cultures.

18. A more detailed discussion of the rationale used to apportion the income can be found in "Ecology and the Economy", Appendix 5, prepared by E. K. Peterson for the Pacific Northwest River Basins Commission.

19. An illustration of pollution control limitations is the air quality of the Los Angeles basin. Despite heroic measures since the early 1950's air quality has steadily deteriorated. From 1966 to 1970 an overall reduction was made in atmospheric hydrocarbons and carbon monoxide but this was more than canceled out by a sharp increase in nitrogen oxides (a major component of photochemical smog). From "The Closing Circle," by Barry Commoner.

20. Energy consumption per capita is approximately proportional to per capita income—*Standard Oil Co., of California Bulletin*, Summer 1970. Also, report of National Economic Research Associates, Inc., *Congressional Record*, July 15, 1971.

21. Daly, Herman E., in "Electric Power, Employment and Economic Growth," before 1971 AAAS Convention. Also see *Cong. Record*, Feb. 8, 1972.

22. Jones, Lawrence W., "Liquid Hydrogen as a Fuel for the Future," *Science*, Oct. 22, 1971, Vol. 174; Anderson, J. H., "The Sea Plant, A Source of Power, Water and Food Without Pollution," International Solar Energy Conference, May 12, 1971.

23. "The First Annual Report of the Council on Environment Quality", August 1970, Chapter IX, *Land Use—The Natural Environment*.

24. Iltis, H. H.; Andrews, P. and Loucks, O. L., "Criteria for an Optimum Environment," *Bulletin of Atomic Scientists*, January, 1970.

# 4

# INTERNATIONAL IMPLICATIONS OF GROWTH POLICY

## *Introduction*

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The international dimension of national growth policies has two components: international constraints or opportunities affecting our national freedom of action, and effects of alternative national growth policies on the world structure.

These two dimensions and their policy implications for environmental policy were discussed by Lincoln Gordon in his paper invited for this project. The material in this Chapter was taken from this paper.

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The United States is not a closed and self-sufficient society, isolated from the rest of the world. Although the proportion of our international economic transactions to the total economy is smaller than for any other major industrial nation, except the Soviet Union, the absolute size of these transactions is the largest in the world. International interdependencies have a major impact on our economic welfare. Even less are we an isolated society in terms of security, of the flow of knowledge and ideas, and of political and social currents.

It follows that the international dimensions of growth policy should not be treated as afterthoughts, or as minor adjustments to completed domestic policies to take account of residual impacts abroad. They should rather be incorporated from the start as an integral element of policy making. In practical terms, that requires participation at the earliest stages by persons knowledgeable in the attitudes and interests of our principal foreign partners and competitors and sensitive to the dangers and opportunities created by our external relations.

The international dimension has two major components: (1) the international impact on national policies, which on the one hand places constraints on our freedom of action, though it also opens wider opportunities for meeting national aspirations than could be accomplished by national action alone; and (2) the effects of alternative national growth policies on the shaping of a world structure which is conducive or antagonistic to the achievement of national goals.

## *The International Impact of National Growth Policy Alternatives*

Before considering the international dimension of growth policy, it may be useful to recapitulate the principal elements determining the rates and directions of growth, most of which have some degree of international interdependency. The major determinants of the rate of growth are (1) the scale and character of investment; (2) the education and health of the people; (3) technological change; (4) the quality and cost of available natural resources (those four elements together largely determining productivity); (5) the size of the labor force; (6) the proportion of the labor force employed; and (7) the hours of work. In analyzing direction of growth, the major categories to bear in mind are (1) the distribution of output among primary products, manufactured goods, and services; and (2) the distribution between private consumption and collective consumption, the latter being subdivided between governmental defense and domestic activities. Finally, there is the international impact through foreign trade in goods and services, international investment, the international flow of technology, and (now of relatively minor importance for the United States) the migration of people and its effects on the labor force. It is through one or another of those categories that national growth policies are constrained, or enlarged, by the international dimension.

Increasing dependence on imported materials other than energy resources need not constrain otherwise desirable growth policies, provided that action is taken to assure adequate worldwide production and availability to the U.S. A vast expansion of oil imports could impose undesirable constraints for both economic and security reasons. It can and should be limited in size and duration through measures of conservation in use and expansion of domestic supplies, especially of low-sulphur coal, with appropriate environmental safeguards.

Derived export dependence requires, in the short, term special attention to continued agricultural efficiency and technological innovation in manufacturing with a steady displacement of low by higher technology production. For the longer term, international cooperation among all industrialized nations should look toward "growth control" to avoid growth patterns desired by none but adopted by each for competitive balance-of-payments reasons. Within the same grouping of OECD members, cooperation is especially important in harmonizing environmental standards and methods of regulation. Identical standards should not be sought in less developed countries, and a degree of relocation to them of certain types of polluting industries is not undesirable.

Growth policies are interlocked with the world structure through (1) problems of strategic security, (2) competition and cooperation among industrialized nations, and (3) the North-South relationship between the industrialized and the less developed nations. Nuclear proliferation is a special concern under (1).

Within the industrialized group, competition should be tempered by cooperation in resource extraction and conservation, environmental protection, and avoidance of trade distortions, together with harmonization of broad growth objectives. There should also be more systematic exchanges of information and experience on national growth issues.

The most serious long-term problems of the world structure arise from growing bi-polarity between rich and poor countries. The major challenge is to find ways of (1) extending the time period for adapting to ultimate limitations on material growth, (2) accelerating the shift of the richer countries toward consumption patterns (services, leisure, etc.) at lower material growth rates, and (3) developing new international economic relationships which can reconcile slower material growth in the industrialized countries with faster material growth (and more effective population control) in the less developed regions. This may ultimately imply significant global industrial relocation.

On all fronts, there is need for clarification of alternatives, improvement of adjustment mechanisms, and identification of issues requiring strategic discrete decisions. Process and institutions require intensive research along with substantive issues of policy.

## *Implications of International Competition*

The question of international competition centers on the inbuilt pressure for maintaining competitive strength even if social preferences within the nation might dictate otherwise.

Lest this be considered an unreal hypothesis, note the official Canadian document on *A Science Policy for Canada* (the "Lamontagne report"), reviewed in *Science* for January 12, 1973. The report calls for a "first generation" policy during this decade aimed at promoting economic growth, while a later volume not yet published is to describe policies designed to serve a broader range of collective social needs. In Professor Lakoff's paraphrase: "Canada has no choice but to keep abreast of the rest of the world. As long as all other developed nations continue to exploit science and technology for economic advantage, it would be imprudent for Canada to stand aside from the competition.

A similar concern is evident in the recent testimony of Pierre Rinfret to the House Ways and Means Committee, to the effect that "American capital would inevitably go into investment overseas as long as the tax laws provide a faster recovery of capital there than in the United States."

As the richest country in the world, the United States is on the leading edge of consumption patterns. Europe and Japan have witnessed Americanization of their lifestyles since World War II, and the Soviet Union and Eastern Europe now appear to be following suit. So are the more advanced of the less developed countries, at least among their middle and upper classes. The merits of these consumption patterns may certainly be disrupted. Since we are on the leading edge, we also have reason to be more aware than others of their disadvantages along with their benefits. Some portion of them may be attributed to advertising and social snobbery. Abstracting from elitist conceptions of what truly constitutes the "good life," however, these patterns do appear to evoke a positive response among consumers everywhere once incomes pass the range of $600 to $1000 per capita.

Family incomes in the United States now average about $10,000. At the "normal" real growth rate of 3 percent per capita per year, that figure should multiply fourfold in less than fifty years. Clearly consumption patterns would change markedly during such an evolution. To cite one important example, the number of registered automobiles per thousand in the American population has risen from 188 in 1930 to 429 in 1970; if the rate of increase of the last twenty years were to continue unaltered, we would pass one per capita (including newborn babies) around the year 2005! It seems plausible to assume that, long before family incomes average $40,000 at present prices, there will be a substantial shift in preferences toward leisure time over work time, toward services over goods, toward higher environmental standards, and perhaps toward preferences for more satisfying but possibly less productive (in the narrow economic sense) ways of working.

Will international competition hold us back from adaptations we might prefer along these lines? Does it, in other words, dictate a kind of mindless pressure for growth, akin to the competition in armaments? Does it distort the growth alternatives, driving away from environmental improvement and other forms of collective consumption? Some international trade theorists would argue that it cannot do so as long as foreign exchange rate changes are available to equilibrate each nation's balance of payments. It might only imply a more rapid closing of the gaps in world income levels, if other nations maintained their commitment to conventional economic growth while we relaxed ours.

What is not clear is whether changes in foreign exchange rates and other international economic adjustment mechanisms can adequately accommodate structural adjustments of this type. It would be a paradox indeed if several of the advanced countries simultaneously had domestic social preferences for slowing down conventional economic growth, but each refrained from doing so because of fear for its balance of payments in competition with the others. If there is validity to the analogy of the arms race, the alternative suggests itself of some form of negotiated "growth control."

It takes no great stretch of the imagination to envisage within a decade or two a degree of economic integration among all the open market industrialized countries at least as great as that which binds the members of the European Community today. Just as the commitment to internal free trade has pushed the European nations to efforts at harmonization of a wide range of economic and social policies, including a start in the environmental field, similar pressures may develop in the larger framework of the Organization of Economic Cooperation and Development (OECD). Monetary unit would necessitate much more far reaching harmonization, approaching a confederal political structure, and that fact is at the root of the difficulties in moving forward toward monetary unity in Europe. Short of monetary unity, however, the realistic alternative to a substantial degree of economic and social policy harmonization would probably have been a breakdown before now in the Common Market itself. If the conception of technology assessment emerges from its present chrysalis into operational machinery in various of the industrialized nations, international collaboration among the responsible authorities might constitute the first faltering steps toward some form of coordinated "growth control."

The expression "growth control" is obviously not intended to suggest that growth is bad or wasteful, as armaments beyond the requirements for internal security would be in a rational and peaceful world. The analogy is valid only for those forms of growth which all components of an international community would prefer to limit if they were making the decision on purely domestic grounds. I would personally place the supersonic air transport in that category, as a clearly uneconomic mode of transportation with questionable environmental effects, which I suspect neither the Soviet Union, France, Britain, nor the United States would ever have undertaken in the absence of concern for international competition, prestige, or their respective balance of payments.

## Environmental Standards

The international dimension imposes two kinds of constraints on environmental policies. There is a range of measures whose effectiveness requires international collaboration, such as ocean pollution control, regional air and water control crossing national boundaries (e.g. in the Great Lakes), and global monitoring. Such matters comprised the bulk of the 1972 agenda for the United Nations Stockholm Conference on the Human Environment.

The second category is a specialized but very important subset of the broad issues: the effects of international competition in limiting national freedom of action to take otherwise desirable measures for environmental protection. Differing standards for pollution control are a new factor affecting relative costs and the comparative position of producers in different countries. At the same time, the severity of pollution is not uniform among countries, and environmental concerns have a lower priority in some than in others.

It would be fanciful to expect world-wide agreement on tolerable ambient air or water pollution limits or on specific process or product standards. Nor is there any rational basis for seeking to impose such uniformity. Poorer countries in particular may understandably accept some pollution as a tolerable cost of industrialization, raising agricultural productivity, and promoting economic growth generally.

The potential effects on trade and investment patterns depend partly on the nature of the controls (whether imposed on products, processes or effluents) and the method of payment of the costs (whether by the industry concerned, and therefore its consumers, or by the general public in the producing countries through taxation and government subsidies). Specific product or process inspection requirements can also easily become a disguised form of international economic protectionism.

There is some reason to believe that the overall effects of environmental controls on the United States balance of payments are not likely to be very large, even with less stringent policies being applied by our principal competitors. The effects on specific industries and firms, however, can be critical, including in extreme cases the relocation of existing plants and in many more cases the decisions on location of new plants. These effects in turn create new pressures for trade and investment protectionism.

Among the more industrialized nations, systematic collaboration is clearly in order to minimize undesirable international economic distortions resulting from national environmental controls. In general, product standards are to be preferred to process standards. Where goods are heavily traded, product standards should be as uniform as possible; and abatement or control costs should generally be borne by producers (and therefore passed on to consumers) rather than offset by government subsidies (1). The Organization for Economic Cooperation and Development (OECD) has already endorsed the "polluter pays" principle as a guideline to member governments, although the implementation still leaves a good deal to be desired. The OECD Environmental Committee also provides a most useful forum for ongoing intergovernmental consultation and exchange of information, and a promising foundation for the kinds of international collaboration suggested here.

When it comes to the less developed countries, however, the issues are more complex. In many of them, industrial activities are so slight that both air and water could absorb much larger quantities of industrial waste without passing thresholds of natural absorption or dispersion. For the same reasons that a rational domestic environmental policy would favor dispersion of large population concentrations and decentralization of industrial production complexes, it could be argued that a rational world environmental policy would favor a broader distribution of high-pollution industries. Moreover, poor societies are bound to give lower relative priority to long-term environmental considerations than to short-term expansion of production and incomes. Hence the possibilities of "exporting pollution" or of "pollution havens" in less developed countries.

In considering national growth alternatives, it would be unwise to give blanket approval or blanket condemnation to international industrial relocation on environmental grounds. Where the pollution concerned involves serious global hazards (e.g., toxic heavy metals), the process should be altered to eliminate such pollution regardless of its location. Where new control technology can produce satisfactory products at comparable costs, it would be absurd to export the old technology to new locations; less developed countries should not repeat the environmental errors of our own past. Where the negative side effects in the new location are substantial, the country concerned should certainly be encouraged to evaluate them fully before initiating a new investment, again learning from the mistakes of the more industrialized nations. That evaluation, however, will be in terms of the standards of the less developed country, which may be quite different from those appropriate to a more advanced nation. But there is almost certainly a significant class of industrial activities whose pollution effects are localized and in which advanced country environmental standards do add considerably to product costs. In such cases, it is hard to see why a comparative advantage in justifiably lower environmental standards in the less developed countries should not be a legitimate factor in international industrial location.

Japan has already begun to encourage the shift of some pollution-intensive industries to the Asian mainland, along with the low productivity labor-intensive industries already mentioned. Her tight employment situation, exceptionally heavy pollution, and strong balance-of-payments position in recent years has made such a policy easier than it would be in the United States today. Its implementation evidently requires effective arrangements for local adjustment, retraining, and reemployment of any displaced workers and capital. Like most such adaptations, it is a line of policy much easier to apply to the location of incremental new investments than to the relocation of existing ones. The institutional mechanisms which might be involved include measures for foreign investment financing or guarantees, the international financial institutions (especially the World Bank and the international Regional Banks), and consultation between government agencies and multinational corporations. In any event, the questions of industrial relocation, both domestic and international, are major matters for continuing research and identification of policy issues as part of the consideration of national growth alternatives.

**International Cooperation: Straitjacket or Opportunity**

Several of the foregoing sections have pointed to the desirability of international cooperation as part of national growth policy making. That suggestion always raises the specter of excessive constraint on national freedom. In the real world, moreover, the difficulties of securing international agreement, the painfully slow pace of deliberation, and the notoriously low efficiency (measured by output per unit of effort) of international institutions often makes national authorities reluctant even to contemplate any derogation of sovereignty.

Yet the trends fostered by technology and economic development all point toward continuously greater international interdependence. In these circumstances, the right kind of international cooperation can be more liberating than constraining; it can on balance enlarge the potential for meeting national aspirations. It is particularly effective in functional areas when the participants in international negotiation include those directly responsible for the corresponding domestic policies, as well as foreign offices concerned with the overall framework of international relationships.

## *Implications of National Alternatives for the World Structure*

Let us turn now to the other side of the coin: the effects of national growth alternatives on the world structure. The United States is neither isolated nor self-sufficient in any major dimension: security, environmental, economic, or ideological. The world framework affects our freedom of choice for better or worse. As the most powerful national unit in both military and economic terms, we exercise—by commission or omission—more influence than any other single nation on the shape of that framework. We can no longer lead by ourselves, but our co-leadership is indispensable. And as the highest income society in the world, with wider margins for discretionary expenditure, we are freer than others to develop new patterns and directions of growth without sactificing universally felt basic needs.

### Growth Alternatives and Strategic Security

Strategic security is a powerful source of pressure for economic growth, a massive diverter of resources from the satisfaction of human needs, and a substantial user of scarce material resources and generator of environmental pollution. In a world of sovereign nation-states, it is an unfortunate but inescapable necessity, which can never be left out of account in considering national growth alternatives. Environmental concerns are simply an added weight in favor of maximum efforts for qualitative and quantitative arms limitations among the actual or potential major powers.

Security concerns may have other impacts on growth policies. A notable example is the relation between nuclear fission waste management and the dangers of nuclear arms proliferation. It is not implausible that by ten or twenty years hence, the major element in strategic arms posture will no longer be the maintenance of mutual deterrence between the Soviet Union and the United States, but instead a joint effort by the superpowers to offset and control the widespread proliferation of nuclear arms to lesser nations (or even organized groups other than governments). Such a posture might be as costly as the present one and considerably more unstable. It follows that the avoidance of proliferation should be given great weight in the choice among energy supply alternatives.

The greatest solvent to security concerns would obviously be a world structure sufficiently favorable to a variety of national aspirations and involving so complex a web of interdependencies that no nation would be tempted to alter it by violent means. That is a distant ideal pending which defensive power must continue to play a large role. The balance between the essentially negative factor of defensive power and the positive factor of mutuality of interest, however, will be greatly influenced by various national policies toward rates and directions of growth.

### Cooperation and Competition among the Industrialized Nations

Implicit in the earlier discussion is recognition of a mixture of competitive and cooperative relationships among the United States and the other major industrialized areas, notably Europe, Japan, Canada, and the Soviet Union. In these days of chronic balance-of-payments deficit and monetary crisis, it would be superfluous to emphasize how severely our short-run economic policies are constrained by international considerations. Nor should competition be opposed as such; it has been and can be a very healthy stimulus to constructive innovation and to efficiency in the allocation and use of all kinds of scarce resources. Just as federal regulation forbids child labor as an instrument of interstate competition within the United States, however, some kind of international governance is required to avoid destructive competition among the industrialized countries while encouraging constructive competition.

Some of the needed forms of cooperation have already been suggested: technological development in resource extraction and conservation; environmental protection standards and avoidance of trade distortions; and harmonization of broad growth policies to fit shifts in preferences in the entire community of advanced nations ("growth control"). Although it may still be at an early stage, there is evidence in all these countries of what Hugo Thiemann terms a "change of phase"—away from an exclusive focus on conventional economic growth as measured by GNP per capita and toward a balancing of such growth with other objectives. Some of those are simply compositional shifts within GNP as presently measured, including a larger proportion of health, educational, and recreational services. Others are not properly measured by GNP, although they might be, such as some forms of environmental improvement. Still others may detract from conventionally measured growth, such as added leisure, participation versus hierarchy in management decisions, or changing attitudes toward work.

There is obviously room for a great deal of diversity in the way in which such changing preferences are implemented in various societies. It would scarcely be desirable that international machinery should force the pace in some or delay all to the pace of the slowest. What is indicated, however, is cooperation to avoid a lag imposed on all through competitive pressures desired by none.

International cooperation can also assist national adjustments through learning from one another's experience. In the Netherlands and France, for example, the national planning organizations (whose basic charter is for indicative rather than directive planning) are trying to analyze the interactions among broad national goals and to quantify the linkages and trade-offs so that policy decisions on growth can be made with better awareness of their entire spectrum of indirect as well as direct consequences. Japan is undertaking major new experiments in industrial relocation. It is well to bear in mind Kenneth Boulding's prophecy that "Japan has had the most rapid voyage through this social space of development, so it is likely to be one of the first societies which will have to face the problems of reentry and of establishing a new, high-level, much more stable, conservation-minded society . . . a more 'looped' economy in which the waste products of society, both material and psychological, will have to be re-cycled and used as raw materials in a continuing circular process (2). In general, while European and Japanese income levels are below ours, their higher densities of population are making them face some issues of urban over-concentration and industrial pollution earlier than we. There is no monopoly on social wisdom, and all stand to gain from maximum interchange of experience, including failures as well as successes, in such fields as population dispersion, land use control, mass transportation, urban improvement, energy conservation, pollution abatement incentives, job satisfaction, and other aspects of growth policy.

The most important single area for cooperation among the industrialized countries, however, has to do with their relations with the rest of the world. It is on the North-South axis that the gravest issues arise relating alternative growth policies to the world structure.

## Directions of Growth in a Bipolar World

Foreign policy attention is currently focused on relations among the five "great power" areas of North America, Western Europe, Eastern Europe, China, and Japan. The avoidance of war among any pair of these nations or regions is obviously the most urgent short-term requirement of a viable world structure. If that can be accomplished, however, it is much easier to visualize a workable affirmative relationship among the industrialized nations, especially the three open-market groups, than between them and the less developed countries. Many of the present trends suggest increasing global bipolarity. In the richer nations there live about one billion people with per capita incomes in the $1,000 to $5,000 range, confident of a fairly steady pace of continuous growth, and with birth rates only slightly in excess of mortality. In contrast, there are almost three billions in the poorer nations, with per capita incomes between $50 and $500, great uncertainty as to their growth prospects, and very high rates of population increase. The intermediate category of semi-industrialized nations, mostly in Latin America and the Middle East, is painfully small.

Even if overall growth rates favored the less developed nations, the difference in population growth would probably more than offset this advantage. And even if the per capita growth rates favored the less developed countries, the disparity in the base is so enormous that the absolute difference in living standards would continue to increase for many decades. Mass famine is still an imminent possibility in several of the less developed regions, and mass malnutrition is more common than not. Levels of education, health, housing, and all the other indexes of measurable social welfare display a corresponding bipolarity. Political polarization between rich and poor is becoming the standard experience of the United Nations and its specialized agencies.

How might these relationships evolve in the middle term, say twenty to fifty years? Three broad alternative scenarios come to mind. A continuation of present trends would suggest a general confrontation between rich and poor on many fronts. A second possibility would involve clusters of less developed countries as satellites of each of the major powers, with preferential trade and investment relations and mutual security pacts providing some binding force for each cluster. The third possibility—most difficult but most desirable—would unite both rich and poor in a world structure offering significant benefits to all its members.

Which course the North-South relationship may follow will be critically influenced by policies on rates and directions of growth.

The accelerated shift away from material growth in the richer countries will be encouraged through market forces by the inclusion of full environmental costs in product prices and by the gradual rise in materials costs. Market forces alone, however, are unlikely to suffice. To give an obvious example, a shift from automotive commuting to mass transit needs not only an increase in the cost of the former, but also major investments in mass transit systems which entail strategic decisions by the appropriate political authorities. Nor is it clear that full environmental costs can always be included in product prices. It is easy to visualize air pollution abatement and marginal energy extraction costs being included in automobile and gasoline prices but not so easy when it comes to the indirect costs of urban strangulation.

To the extent that the shifts involve collective rather than individual consumption, fiscal and budgetary policy can go a long way, provided that the full implications of choices are clarified for the public and legislative authorities. It is interesting in this connection that the Dutch trade union leadership, more sophisticated than most, is reported to prefer that three-quarters of the expected four percent annual increase in output be devoted to improvements in educational opportunities, environmental protection, and social security, taking only one-quarter in additional individual incomes. On the plane of work versus leisure, there is need for institutional arrangements to provide greater freedom of choice in working hours, the arrangement of the work week, holiday schedules, and age of retirement. What is clearly not wanted is involuntary "leisure" in the form of unemployment. The kinds of issues involved here are largely domestic rather than international, although international exchanges of experience can be most useful in informing domestic policy making.

The most difficult aspect of the broad transition envisaged here is the development of new international economic patterns to maintain or accelerate material growth in the less developed countries while it slackens off in the industrialized nations. Present patterns are not so designed. The key economic bottlenecks in the poorer regions today are foreign exchange earnings and availability of capital, both of which are positively correlated with high material growth rates in the industrialized countries. Such growth improves the market and terms of trade for primary product exports from the less developed countries, eases their access to markets for labor-intensive manufactured goods in the richer nations, and facilitates governmental and private capital transfers. There is no logical incongruity in an altered pattern favoring higher material growth in the less developed countries, but how to achieve it requires concerted thought and new forms of international cooperation.

Economic market forces are the best-known examples of smooth adjustment mechanisms, but in some fields analogous results may flow from decentralized political decision-making within a sound framework of national or international guidelines. Many economic markets are very imperfect, fail to include all relevant costs and do not signal the future sufficiently far in advance to permit corrective measures to be taken in time.

Process and institutions, therefore, require at least as much research and innovation as specific substantive policies. Given the rudimentary state of evolution of the world order, that may be even more true on the international than on the domestic front. At the same time, the increasing complexity of technology, the increasing interdependence of nations, and the diminishing margins of resource and environmental tolerance as population and economic growth press against the biosphere suggest that a growing class of strategic and often irreversible decisions will have to be identified and subjected to the most rigorous analysis of their direct and indirect consequences. The creation of both national and international institutions for this purpose is the greatest single challenge in the development of policies toward national and world growth alternatives.

### *Implementing International–Oriented Growth*

The best means for handling the international dimension in such cases will depend on the institutional arrangements designed mainly for domestic reasons; it would be foolish to suppose that the international tail should always swing the domestic dog. The critical point is that the international dimension not be treated as an afterthought, but be built in from the start as an integral element in any policy-making machinery intended to guide national growth or to select among national growth alternatives. There are no existing governmental or private institutions in the United States attempting to formulate such comprehensive growth policies. If such an organization were established it would obviously deal with a much longer time-frame than the four principal comprehensive policy agencies that now exist (the Office of Mnagement and Budget; the Council of Economic Advisers; the Council on Environmental Quality; and the National Security

Council). To have any real impact on operating decisions, any long-term growth policy agency would require organic ties to these present agencies, to the major sectoral operating departments (such as Transportation, Housing and Urban Development, Interior, Commerce, Agriculture, and Health, Education, and Welfare), and to the Congress (including the new Office Of Technology Assessment).

Without specific proposals for such machinery, which would be judged mainly on domestic grounds, it is not possible to specify how best to incorporate the international dimension. The following points, however, indicate some of the specific actions and institutional mechanisms (some existing and some new) appropriate to the suggested lines of policy.

### Import Dependence: The Materials Problem

1. *Stockpiling of and substitution for exotic imported materials.* Stockpiling could be handled by existing machinery (successor to Office of Emergency Preparedness for this purpose). Research might be in Bureau of Standards or stimulated through NSF program of Research Applied to National Needs (NSF/RANN).
2. *Conservation of depletable minerals, including incentives to and research on recycling and process and product improvement.* This is mainly a domestic policy field, in which EPA and CEQ are already engaged. Removal or reversal of transportation rate preferences for virgin materials is one obvious example of the several appropriate actions. Since primary material market prices are very sensitive to short-term demand and supply fluctuations but do not provide adequate long-term advance warnings of prospective scarcities, government-sponsored research to anticipate shortages and facilitate conservation is warranted to supplement normal market incentives in these directions.
3. *Inclusion of balance-of-payments considerations in environmental decision-making affecting domestic versus imported materials supplies.* This should be one explicit criterion for possible exception to otherwise desirable environmental quality standards, including federal preemption of State or local standards where necessary. It would require stern administration to reject specious claims or threats of abandonment of individual mines or smelters. *A floor might be desirable setting a maximum limit to the degree of reduction in standards acceptable on balance-of-payments grounds.* To justify relaxation of standards, the import swing should be required to be of significant magnitude. Formal endorsement might be required from those units of the Departments of Interior and State involved in in-

ternational study groups or international environmental coordinating activities in relation to the specific material under review.

4. *International cooperation in geological surveying.* This point essentially involves a review and possible intensification of efforts underway, including resource surveys financed through the United Nations Development Program, the application of earth resource satellite information to this end, bi-lateral technical assistance programs, and the training of geologists from less developed countries. Other large material importing nations should be persuaded to collaborate in similar activities.
5. *New relationships between multi-national corporations and host governments, especially in less developed countries.* These relationships have been rapidly evolving in recent years, with the development of new forms of concession contracts. They include arrangements for joint ventures, management agreements coupled with long-term purchase contracts, and arrangements for voluntary periodic renegotiation. Primary material development should have priority in the lending and guarantee activities of the Export-Import Bank and the OPIC. Consideration might also be given to government guarantees in the most risky cases to put a floor under possible future price fluctuations. In addition, in view of the sensitivity of natural resource industries to political charges of exploitation, a larger involvement of the World Bank and international Regional Banks should be sought in the financing of materials development ventures.
6. *Cooperation with other importing nation governments to avoid costly scrambles for scarce materials.* The first requirement here is for organized cooperation in monitoring of market situations and prospects. This can best be done through commodity study groups, a number of which already exist. In order to avoid the political criticism of apparent "buyers cartels" the principal supplying nation governments should be invited to participate in such commodity study groups. The main emphasis should be placed on assurance of adequate and geographically diversified supplies, but in market crisis situations, such as those that accompanied the Korean war, cooperation among importers can avoid hoarding or other forms of non-productive competition to corner supplies.
7. *Adjustment of bi-lateral economic policies in relation to major suppliers.* The importance of future raw materials supplies should be regularly taken into account in the formulation of aid, technical assistance, and investment policies. The appropriate locus of this responsibility depends on the organization of foreign economic policy-making generally, which is understood to be under review.

8. *Exploitation of deep seabed minerals.* The responsibility for development and negotiation of a United States position concerning some form of international control regime rests with the Department of State as part of its general preparations for the United Nations Conference on the Law of the Seas scheduled to begin late this year. The Department of the Interior works with the State Department in this effort. There have been some informal discussions of a possible interim agreement among the major countries with interest and potential for deep seabed exploitation (Japan, Germany, and possibly others as well as the United States).
9. *Materials policy coordinating agency.* The points made above suggest a need for some focussed responsibility to follow all aspects of supply and demand for depletable materials and to recommend appropriate action to the various operating agencies concerned. Since in almost all cases supplies come partly from domestic sources and partly from abroad, any such coordinating agency would have to deal with both domestic and international aspects.

### Energy Resources: The Critical Case

The establishment of an Energy Policy Coordinating Agency is an obvious necessity and a prerequisite to implementation of the lines of policy suggested below. It should have extensive powers for promotion and financing of research in the various energy sectors and authority for initiative as well as conflict resolution among operating agencies. The issues involved in adequate supply and conservation of energy are so pervasive, however, that it would be foolish to suppose that all operating responsibilities effecting energy could be consolidated in a single agency. The elements of energy policy might include the following.

1. *Energy conservation in use and in conversion to electric power.* As suggested above, market forces will work in this direction as relative costs of energy rise, but they will work too slowly to accomplish the needed results. A coordinated set of energy conservation policies would include higher minimum standards for building insulation, a steeply graduated excise tax on automobile engine horsepower, phased in over a number of years, greatly enlarged encouragement and financial help for the building of intra-urban mass transit systems, incentives to shift freight transportation from highways to railroads and inland waterways, more intensive research on magneto-hydro dynamics, experimentation in local "total power systems," etc. The NSF/RANN program is doing some work in these directions, but on much too small a scale.

2. *Domestic fossil fuel expansion.* The problem of price and other incentives for increased oil and gas exploration and production is both too

complex and too well-known to require elaboration here. The major additional need is for intensive expansion of use of low-sulphur western coal, including appropriate public land policy changes to that end, greatly intensified research in land reclamation from strip mining on low-slope dry lands, and gasification and liquefaction. On the environmental policy side, there is a strong case for federal preemption of environmental standards affecting national energy supplies.

3. *Deferral of commitment to major reliance on nuclear fission and speeding up of research on long-term alternatives.* The President's energy message of June, 1971, placed major emphasis on nuclear fission, especially with liquid metal breeder reactors, as the prime source of expanded power supplies from the middle 1980's forward. Uncertainties with respect to reactor safety, waste product control, and possible weapons diversion suggest that a major commitment to applied nuclear fission should be deferred until much more extensive technological and social research demonstrates that its risks are acceptable. Given the ample supplies of fossil fuels, nuclear fission need not be a major alternative to excessive oil imports for some decades to come. At the same time, it would be desirable to enlarge research on nuclear fusion to the maximum that can be usefully absorbed and also to intensify research on the effective use of solar energy for both low-grade and power production purposes. The Atomic Energy Commission and the National Science Foundation are adequate instrumentalities for this purpose, given sufficient funds and guidance from the energy policy coordinating agency mentioned above. Geothermal energy should also be included in an enlarged research program.

**Derived Export Dependence**

1. *Stimulation of agricultural productivity and technological innovation in manufacturing.* Collaborative efforts should be developed among the Departments of Agriculture and Commerce and the National Science Foundation to identify and encourage promising research leads.

2. *Displacement of labor-intensive industries to lower-wage countries.* Any policy working in this direction would require a more effective program of industry adjustment assistance than has thus far been associated with international trade legislation. If that condition could be met, so that displaced labor and capital could be assured of opportunity for engaging in higher-productivity work, market forces would largely accomplish the objective. They might be reinforced through policies of the international financing insitutions, the Export-Import Bank, and the OPIC. It would also be helpful to commission a special study of Japanese experience along these lines.

### International Competition and Long-Term Growth Policies

The concept of negotiated "growth control" among industrialized nations set forth here requires research and informal exploration and consultation as a preliminary to policy formulation and implementation. The needed research would aim at the identification of areas of technical development or product development not desired for domestic needs but being fostered exclusively for international competitive reasons. It should also look for cases in the converse, i.e., areas desired domestically but being retarded for international competitive reasons. Exploration and consultation would seek to identify corresponding areas in the principal competing nations, especially Western Europe and Japan. If some or all of the governments concerned establish formal agencies for technology assessment, those agencies would be a major source of information for this purpose. Pending that development, environmental protection agencies in the several countries would be a logical source. After the assemblage of information of this type, the OECD would probably be the best forum for initiating intergovernmental discussions looking toward coordinated "growth control."

### Environmental Standards

1. *Environmental cooperation among industrialized countries.* The EPA and CEQ are already involved in international environmental policy discussions along the lines suggested here. The OECD and the UN Economic Commission for Europe (ECE) provide mechanisms for this purpose, and a further one will be added when the United Nations environmental program agency is established in Nairobi. In the forthcoming trade negotiations on non-tariff barriers, there will be further opportunity to negotiate the principles suggested here.

2. *Export of certain types of polluting industries to less developed countries.* This topic will certainly be on the agenda of the new UN environmental program agency, one of whose central concerns is the relationship between environmental protection and economic development in the poorer countries. As stated previously, the questions of industrial relocation, both domestic and international, are major matters for continuing research. The aims of such research should be to clarify hazards, new technological requirements and costs, and to identify activities suitable for relocation. (Development of hydro-electric power in South America and Africa for energy intensive electro-chemical and electro-metallurgical industries suggests itself as one major possibility.)

### Cooperation and Competition Among the Industrialized Nations

Several European countries and Japan are far ahead of the United States in the development of long range analysis and planning on broad issues of national growth and development, including land use control, transportation systems, and industrial location. Systematic research is indicated to canvass these experiences and to analyze the extent to which they might be applicable to American conditions.

### Directions of Growth in a Bimodal World

This section sketches a number of major areas for needed ongoing research concerning long-term growth alternatives. They include:

(1) Strategic sectors affecting long-term regional and global growth limitations. To the items listed there should be added the fundamental issue of atmospheric heating and climatological modification through energy use, which might lead to the need to concentrate on solar energy, even at much greater cost, as the ultimate reliance of mankind.

(2) A second major area concerns ways and means to accelerate a shift in growth patterns in the wealthier countries away from material-consuming growth.

(3) The third major area concerns changes in international economic patterns (trade, investment, industrial location, etc.) to permit more rapid material-consuming growth in the poorer countries.

### Conclusion

These areas would be among the key concerns of any national long-term growth policy agency that might be established, and should constitute a major part of the agenda for the in-house and external research of any such agency. Pending the creation of such an agency, a start might be made under the auspices of NSF/RANN, supplemented in specific cases by resources from EPA and CEQ, other interested government agencies, and private foundations and research centers.

## NOTES FOR CHAPTER 4

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2. Kenneth E. Boulding, *A Primer on Social Dynamics*, Free Press, New York, 1970.

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20. Weinberg, Alvin, "Long-Range Approaches for Resolving the Energy Crisis, presented before the ASME Symposium, The Energy Crisis, Long Term Solutions, New York, November 29, 1972.
21. *World Energy Demands and the Middle East*, the 26th Annual Conference of the Middle East Institute, Washington, D.C., September 29-30, 1972. Part I.

# PART II

# COPING WITH ALTERNATIVE FUTURES

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# II

In Part 2 the implications of economics and human behavior for growth policy and the environment are discussed.

In Chapter 5 Growth and Behavior are discussed by several authors presenting several interesting and innovative concepts relating human behavior to the environment and environmental policy. The editors combined these somewhat disparate papers under a central theme that man's short-range and self-centered thinking, sometimes enhanced by a lack of commitment and responsibility, are primary behaviorial factors contributing to environmental degradation. A second theme somewhat common to the papers contained in this Chapter is man's emotional response to "crises".

The possibility of effecting a major change in the attitudes of society is discussed by one author and he concludes that the crisis label may result in no action. This happens because crisis denotes an impossible situation in which one merely "hangs-on" and rides out the developments. In reality, there is no crisis but an evolving problem which can be solved only by diligent and continuous hard work.

The evolution of human consciousness and the brain are discussed in another paper. The author relates evolution to population density, showing that man created information and coded it into concepts that permitted new social roles to limit social interactions to tolerable levels. He concludes that, as evolution continues, man will be linked into a single, world-wide communication network. Ability to function in this network and to manage his increasingly multidisciplinary activities will require delineation of concepts and the linkages among them.

In the final paper a systems viewpoint of human behavior is presented. The concepts presented view man as sometimes reacting emotionally in predictable fashion, not, as he would like to picture himself, acting from rational thought. What man does is often different from what he says he will do. This author also concludes that the crisis label should be removed from the environment to encourage more rational action.

In Chapter 6 the relationship between Growth and Economics are discussed in some detail. The classical economic concepts, which will continue to remain valid, are reviewed with emphasis on their effects on environmental planning. New concepts shaping new economic viewpoints are also presented. The author applies the concept of entropy to economics, concluding that waste accumulates faster than useful output but also concludes that the situation is not hopeless. By applying knowledge and energy we can escape the "entropy trap". The author reviews changes which he expects will accompany growth, discusses the costs of change and concludes that these costs can be borne, principally from added profits realized from economic growth. In conclusion he outlines a proposal for a government-business growth policy which could lead to an improved quality of life.

Another author introduces the concept of sustainable growth, defined as economic growth which provides sufficient discretionary income per capita to achieve a desired quality of life without environmental degradation. He outlines action required now to achieve such growth. These recommendation include developing a concept of legacy for future generations and finding ways to coordinate goal-setting and planning functions to develop indicative, integrative planning.

# 5
# GROWTH AND BEHAVIOR

## *Introduction*

Short-range and self-centered thinking coupled with a lack of commitment and responsibility are primary factors of human behavior contributing to environmental neglect and degradation. In this Chapter some of the major reasons for these attitudes and methods for dealing with human factors affecting the environment are discussed.

Concepts of expanded ownership, developed by the Sabre Foundation, and improvement in the quality of the work environment taken from Peter Barth's invited paper are presented as possible methods for improving man's sense of commitment and responsibility.

Garrett Hardin discusses the possibility of effecting major changes in the attitudes of society and the "crisis" label so often associated with the environment. He concludes that this label may be necessary to initiate action but emphasizes that hard work over a long time is what is really needed.

Murray Bowen takes a systems viewpoint of human behavior. He discusses the communication of emotional reaction to crisis, the maturity of society, and approaches to solving environmental problems based on increasing responsibility and consistency between what we say and what we do. He also recommends that the crisis label be removed from environmental issues.

## *Human Short Range Thinking*

One of the reasons we do have environmental degradation is that mankind stresses short-range goals and tends to be most concerned with individual gain, even when he may realize this gain is obtained at the expense of society as a whole. Hardin aptly illustrated this tendency in an example he called "The Tragedy of the Commons" (1).

Hardin describes a common pasture in which neighboring herdsmen graze their animals. When the population becomes sufficiently large increased grazing will have detrimental effects on the pasture and each herdsman realizes this. However, when deciding whether or not to add another animal to his herd, he asks himself,

> "What is the utility to me of adding one more animal to my herd? This utility has one negative and one positive component.
>
> 1. The positive component is a function of the increment of one animal. Since the herdsman receives all the proceeds from the sale of the additional animal, the positive utility is nearly +1.
>
> 2. The negative component is a function of the additional overgrazing created by one more animal. Since, however, the effects of overgrazing are shared by all the herdsmen, the negative utility for any particular decision-making herdsman is only a fraction of -1.
>
> Adding together the component partial utilities, the rational herdsman concludes that the only sensible course for him to pursue is to add another animal to his herd."

When this process is repeated by all the herdsmen, serious environmental degradation occurs and ultimately all suffer loss. The parallel of this example to our present environmental behavior is obvious.

## *Responsibility and Personal Commitment*

Another factor contributing to our problem is the lack of a feeling of responsibility evident among many of our citizens. In part this is due to a decrease in commitment to personal possessions and to the area in which they live. This could be offset by expanding ownership, perhaps by making ownership more easily attainable. Responsibility and commitment could also be improved by improving the quality of the working environment.

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### **Rental Economics**

Rental economics is a term used to describe the temporary commitments increasing numbers of individuals and institutions make when they rent clothing, automobiles, household furnishings, housing and many other things. The trend is most dramatic in housing. In "Future Shock" Alvin Toffler observes that "as late as 1955 apartments accounted for only 8 percent of new housing starts. By 1961 it reached 24 percent. By 1969, for the first time in the United States, more building permits were being issued for apartment construction than for private homes." People increasingly want minimum involvement to survive the uncertainties of rapid change.

This trend has two implications for environmental quality. First, the reduced sense of identity, commitment and responsibility encourages indifference to the environmental. Second, there is a possible positive effect. Rented items are the responsibility of the owner for major maintenance. This could incentivize the market and increase the demand for products designed for longer life and lower maintenance requirements.

## Expanded Ownership

Expanded ownership is a term used to characterize various methods whereby ownership of income-producing capital can be made available to those who have little or none. Ownership may strengthen one's sense of identity with the goals of an enterprise or of the community.

The concepts of expanded ownership are delineated in a study directed by John McClaughry for the Sabre Foundation. Excerpts from the report are presented below.

> The men who founded the United States of America—John Adams, Thomas Jefferson, and James Madison in particular—believed that a widespread distribution of property ownership was essential to the establishment of republican self-government and the preservation of individual liberty.
>
> Today the idea of a private property base for free government and a free society is increasingly called into question. Three differing views of public policy exist:
>
> 1. Those who find the concentration of ownership and economic power desirable, as Alexander Hamilton once did, and oppose any public policy which would alter the status quo.
>
> 2. Those who advocate increased governmental control of the large concentrations of ownership and economic power in the name of "the people" including those who favor government ownership of the means of production.
>
> 3. Those, as yet few, who believe that free government and individual liberty must continue to be based on the widespread ownership of genuine private property, and who thus favor a public policy of expanding ownership opportunities to achieve that objective, while at the same time forestalling demands for government controls and socialization.

The Sabre report, describing methods for expanding the ownership of property to those who have little or none of it, is squarely based on this third public policy position.

The Sabre Foundation's study makes a strong case in favor of expanding classic private ownership opportunities. One part of the case is the link that exists between private property ownership and such traditional virtues as individual liberty, respect for law and order, responsible political participation, economic understanding, and individual productivity. Another part of the case is the link between the use of private capital and entrepreneurship in production and the growth of wealth. It has been the productivity of capital that has generated the huge rise in incomes and accumulation of wealth in modern times. It is the productivity of capital whose fruits finance the growing welfare sector of the economy and the increased consumption of public goods.

The Sabre study recommends an extensive national commitment to expanded private ownership opportunities to broaden the ownership of productive capital and consumer capital. This would mean that governmental policy would be devised to enlarge ownership in United States corporations. Programs to encourage individual purchases of homes, farms, and small businesses would be strengthened and extended. Tax policy would give incentives to employees to buy stock in corporations where they work and to employers and owners to provide the opportunity. The study proposes that the President and the Congress establish a Commission on Expanded Ownership to further explore and implement ideas to promote more general private ownership.

All these current controversies center on the future of the private ownership of productive and consumer capital. The broader that ownership is, the stronger can be the ownership voice in the councils of public and private policy-making.

## Productivity and the Quality of the Work Environment

Productivity reflects how well managers use corporate resources. In part, productivity is a function of the attitude and motivation of managers and workers. If they can genuinely feel a personal identity which the activities of the company their personal productivity will tend to increase. It seems reasonable to assume that, under conditions of increased identiy with company activities, they might also experience and increased identification with the environmental responsibilities of the company.

Peter Barth observes, "A job is no longer valued solely as the means of acquiring income. It is also valued in terms of the opportunities it affords to satisfy equally basic social and psychological needs." Other observations from his invited paper are presented in the remainder of this section.

Although we have been prone to treat work as a discrete segment of life because of its temporal and geographical separation from the home and the community, it is becoming quite obvious to social observers that life cannot be so neatly compartmentalized. The quality of work is inextricably tied to the quality of life, with the former conditioning and setting limits on what may be achieved in the latter. Research has established that the adverse of employment experience are not confined within the boundaries of the workplace, but can spill over into virtually every area of life functioning—personal, familial, social and political. Work for some may be the principal means of earning "the coin of fun," but it is also a potent determinant of the utility or what is purchased.

We are beginning, with the aid of research, to appreciate the pervasiveness of work problems throughout the population. We have learned, for example, that the "blue collar blues" is not an affliction experienced by a limited segment of the work force, but is a term more appropriately applied to a wide range of workers holding jobs with common attributes at numerous points throughout the occupational hierarchy. Although the assembly line worker continues to be the example par excellance of the dysfunctional consequences of scientific management and bureaucratic rationalization, his frustrations are not nearly so unique as was once assumed. Just as there is impressive commonality of values sought in employment, so too is there a wide sharing of the frustrations induced when the goals of workers are thwarted by the structure and organization of work systems. Excesses in routinization, job simplification, rules of conduct, and the imposition of authority affect white- as well as blue-collar workers, professionals as well as laborers, and managers as well as rank-and-file employees.

But how can we gauge the quality of the working environment? What are its major dimensions? What indices can be constructed and what statistics can be compiled to enable us to measure the impact of the work environment on individual well-being, to determine where problems are more and less severe, to chart changes over time, and to assess the gains achievable through private action and public policy? It is this measurement process which will transfer issues of work quality from the realm of pure conjecture and polemic to the arena of social policy and programs.

A vital distinction should be made at this point between the objective *determinants* of dissatisfaction, the subjective *experience* and attitudinal expression of dissatisfaction, and the larger behavioral outcomes or *manifestations* of dissatisfaction. There is little evidence that the objective circumstances of workers, whatever criterion is used, have significantly deteriorated over the years. Indeed, the application of most economic yardsticks would reveal considerable progress in assuring secure and renumerative employment. To some extent what we may be witnessing is the growing tendency of workers to critically evaluate their circumstances and to articulate such evaluations both in words and deeds. As more is expected of employment, particularly its non-economic features, more is going to be found lacking. In addition, in areas where dissatisfaction has long been experienced, workers may now be less willing to accept and adapt to it as an inevitable requirement of employment.

In short, there may be some striking parallels to be drawn between what is now being observed in employment and what has already occured elsewhere on the social scene, particularly in the civil rights area. Suffering in silence is no longer a commendable virtue. The benefits of the forceful expression of grievances and militant action to correct them have been established for all to witness.

Although existing data bearing on the question of trends in discontent are ambiguous, the evidence regarding the distribution of satisfaction and dissatisfaction throughout the labor force is reasonably clearcut. Discontent is more common to black than to white workers, more prevalent among youth than among older workers, more frequent in some industries than in others, and more concentrated in some occupational categories than in other groupings. While individuals higher in the occupational hierarchy are far less prone to express dissatisfaction than those lower in the structure, there are also notable differences within gross occupational classes: Discontent is more endemic to workers whose jobs are fragmentized, routinized, allow little opportunity for autonomy, yield low wages, offer little security, and subject them to hazardous or unpleasant working conditions.

The existence of substantial "pockets" of dissatisfaction is hardly a recent revelation. Yet worker satisfaction more often has been regarded by organizational managers as a serendipitous outcome of employment than a condition to foster and nurture. However, there is now being created a body of data which should argue compelling for its acceptance as a major organizational and social goal.

1 For the worker, the consequences of dissatisfaction may be profound as well as pervasive. A recent study of aging found level of work satisfaction to be the most powerful predictor of longevity, surpassing the predictive ability of all other variables examined. This relationship is all the more credible in light of the evidence that dissatisfaction can manifest itself in various symptoms of poor physical and mental health, and the suspicion that it may be a factor underlying excessive use of alcohol and drug abuse. Although the broader personal outcomes of dissatisfaction have not yet been fully traced, it is beginning to reveal itself as a potent influence on the quality of non-work life, including the

richness of leisure and the extent of involvement in the social and political affairs of the community.

2. For the employer, dissatisfaction has been found to be a factor in labor turnover, absenteeism and tardiness; it may be a important moderator of productivity and product quality; and it is increasingly viewed as a cause of sabotage and other counterproductive work behavior.
3. For society, dissatisfaction may impede productivity growth and contribute to higher price levels; it may be an important factor underlying anti-social behavior and encourage the growth of social and political alienation; and it surely retards the development and value of the Nation's manpower resources.

These are not, of course, firmly established principles which have gained universal acceptance, but neither are they merely the idle speculations of social theorists. A body of research and experiential data is nowbeing assembled which appears likely to engender a new appreciation of the varied consequences of worker discontent. Hopefully, also, it will encourage the development of innovative approaches to the design of jobs and work environment which may remedy it.

Before considering what directions such remedial efforts might take in the job satisfaction area, it may be instructive to review what actions have already been taken to protect and improve the physical health and safety of workers with view to assessing their applicability to job satisfaction.

In enacting the Occupational Safety and Health Act of 1970, the most ambitious legislation in the area, Congress declared its intention "to assure so far as possible every working man and woman in the Nation safe and healthful working conditions." It imposes on employers the legal obligation "to furnish to each of his employees employment and a place of employment free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees," and assigns to the Secretary of Labor the responsibility for promulgating and enforcing occupational safety and health standards.

Although the full potential of this legislative remedy for health and safety problems is yet to be realized, unqestionably it must be supplemented by actions on a number of other fronts. These include the more thoughtful design of equipment, jobs and work environments, the sensitization of employees to occupational hazards and the encouragement of positive safety attitudes and habits, and the intensification of research enabling the more precise specification of occupational hazards and the health consequences.

Given the state of existing knowledge, it should be possible in time to build into jobs and work environments sufficient safeguards to effect impressive reductions in the frequency and severity of occupational injuries and illnesses, including those which stem from on-the-job pollutants, of special interest to EPA. The principal impediments to achieving this goal may be less a matter of know-how than the knotty question of costs and how they are to be apportioned.

## *Changing the Attitudes of Society*

If man's perception of the environment is incomplete and if his thinking sometimes emphasizes short-term gain to the detriment of the long-term, can his perception be changed? Garrett Hardin believes it can, and cites recent attitudinal changes experienced in this country. However, he suggests that labeling the environmental problem as a crisis is misleading, but perhaps necessary to assure action. His discussion, taken from his invited paper is presented below.

The basic question raised by the analyst of environmental problems is, "What must we do?" So staggering is the roster of things that we really should do, and so fundamental are some of the changes in economic and social arrangements that he recommends, that it is not long before the environmentalist asks, "What *can* we do?" Politics, as some one said, is the art of the possible, and there is little point in saying we must have pie in the sky if meteorology tells us we can't. What *is* possible? What is not?

Recent events justify out being much more optimistic about the possibility of change than we could be even so recently as a decade ago. It is important that the broadening of the dimensions of the possible receive wide publicity, because we are operating in a realm of truth that is populated by what Robert K. Merton called "self-fulfilling prophecies." What is possible is determined partly by what we think is possible. Politics may, in fact, be redefined as "the ethics of thinking the possible and the art of bringing it into being." In use, this will probably prove to be a more responsible definition than the usual one of politics as "the art of the possible," which is too often used as an excuse for fiddling while Rome burns.

Events of the last decade give us valid reasons for doubting what Galbraith has called "the conventional wisdom" about the possibility of rapid social change (2). Conventionally it is held that nothing less than generations will suffice to bring about social change whenever: (a) the topic arouses strong emotions; or (b) the reform called for is more than "incremental," i.e., a succession of tiny steps. Discussion of the second point is deferred for the present, as we look into the effectiveness of emotions in preventing change.

The decade of the '60s was marked by a sustained drive to being an end to "compulsory pregnancy," i.e., to remove abortion-prohibition laws from the statute books (3). As one of perhaps two dozen activists in this area I was repeatedly cautioned that no rapid change was possible in so emotional or "controversial" an area. One wise elder statesman in the medical world told me that he agreed with me that abortion-on-request was desirable, but that he felt that the most we could hope for the present was a so-called "therapeutic abortion" law that would permit abortions only in hardship cases: threat to life of mother, serious threat to her mental health, probability of a deformed child, and for relief in cases of rape and incest. It would be, he thought, a hundred years before society could bring itself to permitting abortion-on-request (4).

That was in 1965. Within a mere five years two states passed abortion-on-request bills; and in January, 1973, the U.S. Supreme Court ruled that state laws could not abridge the right of a woman to have an abortion her doctor was willing to perform.

History has thus given a critical testing of the conventional wisdom that it takes generations to bring about change in highly emotional areas. Few areas were as emotional as abortion in 1963, yet it took only ten years, not a hundred, for a small band of abortion activists to create the new climate of opinion on which the Supreme Court opinion could rest. Such a rapid change in a highly emotional area should be an immense encouragement to all Utopians. Now that we see that substantial alteration is possible, the responsibility for being *right* in our goals should weigh more heavily upon us.

### The Illusion of Crisis

The word "crisis" stands for a curious idea, half fact half fable. A medical crisis, more often seen (or perhaps imagined) a hundred years ago than now, is a mixture of pathology and drama. At a heart-clutching "turning point"—the literal meaning of the Greek root—the patient suddenly and dramatically starts on the road to recovery or he dies. The medical crisis is marvellous for the stage; occasionally it is even encountered in the sickroom.

In a crisis there is nothing much that anyone can do except hold on tight, pray, if you are religious, or rub a rabbit's foot if you are superstitious. But you cannot really do anything at the critical point, which (for better or worse) will soon be over. . . . In Chamberlain's mind, the troubles of Europe toward the end of the '30's, had reached a crisis. A concession here, a concession there—and surely it would soon be over? . . . Please?

He was wrong, and history marched on to produce the Second World War. The underlying troubles were much more enduring than a crisis. What was required was not mere holding on (or prayer or incantation), but hard thought and prolonged effort: blood, toil, tears and sweat, in Churchill's words.

It is significant that we have a name for the time-limited crisis, but no word for its time-extended contrast. We speak of a "chronic condition" but lack the needed noun. Chronos? This would do if word-and-meaning were established—but they are not. Perhaps people don't want to recognize realities of this sort. A crisis is good theatre; the grinding demands of a chronic condition seldom is. Willing not to think about the reality, people are quite content to muddle along without a name for it.

There is no environmental crisis. We are confronted with no dramatic turning point that will soon be past if only we will pray or curse or hold our breaths. The conditions that have produced our present trouble are still with us, in greater degree every day. Without effort on our part, there will be no change for the better, and probably no sudden change for the worst. Tomorrow will simple be a little worse than today, and the next day still worse. Holding one's breath is futile; sweat and toil are what the situation demands of us (accompanied, no doubt, by unavoidable blood and irrelevant tears).

It is tempting to the reformer to use the rhetoric of crisis to arouse his audience. He should resist the temptation. The dynamics of chronos (if I may use the word) is different from the dynamics of crisis. The worsening is not sudden but gradual and almost imperceptible. When the fears aroused by the word crisis are not soon realized a "backlash" is all too likely to develop, and the environmental baby may be thrown out with the bath water of "crisis." The understandable result is a book like *The Doomsday Syndrome* (5).

The expectation of crisis interferes with our perception of world events and with our ability to foretell, recognize, and react to approaching catastrophe. We are trapped by this implicit argument:

1. A crisis must occur before the public will take action.
2. There is no crisis now.
3. We will recognize the crisis when it comes.
4. In the meantime nothing can be done.

The worst errors center around the third point, our perception of reality. As has been said before, "Nobody ever dies of overpopulation" (6). Deaths of chronically malnourished people are attributed variously to cyclones, cholera, tuberculosis, leprosy, riot, civil insurrection and war. Even starvation is seldom recorded as the cause of death: the diseases favored by malnutrition are the "causes" of choice when it comes to filling out death certificates. Worse, in times and places where starvation is most serious no one is filling out death certificates; all too often no one is witnessing death and reporting it to the outside world. Thus are our perceptions protected against recognizing a deperate condition which, were it recognized, would call for action (which we try to avoid).

The city of Calcutta stands as a symbol of our expectations and our moral paralysis. For several decades its desperate situation has been universally recognized, both inside India and out. Paralyzed, the world waits for a crisis to overtake Calcutta, at which point massive intervention would seem justified. But the crisis never comes. As Geoffrey Moorehouse has noted (7), the spectacular and critical events we might label disintegration, collapse and breaktown, seem not to occur. Instead, we are witnessing "something more akin to petrifaction" of the total organism we call a city. This is not a crisis; and so we do nothing.

Almost everywhere, man's situation is "desperate but not critical." Is this qualified judgment a cause for rejoicing? Only if we can bring ourselves to take action in a situation that is merely desperate.

## *Human Consciousness and Management of Multidisciplinary Activities*

As early life forms evolved into modern man, consciousness also evolved. John Calhoun believes that development of human consciousness was influenced by population density. Eventually man had to develop a "conceptual space" to replace physical space as a means of maintaining social interactions within a tolerable level. Conceptual space, the ideas available to an individual, provided a means of defining different social roles which buffered man from too many social interactions. Calhoun traces the stages of evolution of consciousness and concludes that we are on the threshold of a new domain of consciousness.

He states that evolution of the brain necessarily accompanied evolution of consciousness. To enter the new domain of consciousness, Calhoun believes that man must develop a prosthetic-synergistic brain. The brain must be prosthetic in that technological aides to information processing will become increasingly important. He believes this is so because man will be linked into a single, world-wide communications network. The brain must be synergistic in order to effectively direct the multidisciplinary activities of this universal, interdependent network.

## Influence of Population Density on the Evolution of Consciousness

The evolution of consciousness has required two billion years. Most of this time has been required to consolidate living matter into cellular structures and to develop multicellular organisms with neural nets. Late in the evolutionary process, man developed and initiated a sapient domain of consciousness which Calhoun calls the Cultural-Conceptual Domain. During this domain culture superceded genetics as the means for increasing consciousness and responsiveness. Environmental structures, both physical and social, were designed by man as prostheses to the biological brain. Thus, man's brain evolved into a prosthetic-social brain.

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At the time of the beginning of the Cultural-Conceptual Domain man had reached a density-dependent equilibrium with the natural environment in which, as with other animals, his numbers were in harmony with resources. A by-product of having evolved at this low density and as a small group-living social animal was a genetically acquired tolerance and need for a certain rate of meaningful contact and interaction with associates. This required social interaction at a particular rate consistent with living in a territory approximately 15 miles in diameter and as a member of a small group.

Socially speaking, density became synonymous with meaningful interactions per day. As population grew humanity required a redefinition of "space" to include some parameter that could maintain interactions within tolerable limits despite increases in physical density. In prior studies we have shown that the creation of information and its codification into concepts that permitted definition of new social roles represented the needed new kind of space.

Any individual's occupation of a social role buffered him from excessive interaction with individuals occupying other social roles not closely associated with his own. This new kind of space, the total pool of information that may be condensed into concepts permitting elaboration of social roles, the linkage of large numbers of individuals into communication networks, and the devising of technologies for acquiring and fabricating resources, may be designated as "conceptual space." Since, from a social interactional perspective, density must be maintained constant, it follows that additions of conceptual space must keep pace with increases in population. Soon after the beginning of the Cultural-Conceptual Domain, conceptual space became more important than physical space. Furthermore, the number of persons alive at any time provides an approximate index of the amount of conceptual space then existing.

As conceptual space increases the total ideas available to any individual increases. To the extent that these ideas are acquired and utilized the capacity and potentiality of the individual increases.

One of the environmental structural categories in this evolution of consciousness and brain involves the linkage of people together into effective socio-political networks. In the past each revolution of consciousness has been marked by an enlargement of this network. At the conclusion of the Cultural-Conceptual Domain all the world will be bound effectively into a single such communication network. That time, a half century from now, will mark the termination of the domain during which increase in numbers of individuals will augment consciousness. Depending upon how we choose to guide further population change, the upper optimum world population will stand between 6.2 and 9.0 billion. Beyond that additional individuals will merely interfere with that metabolism of information which is prerequisite to further increase in consciousness.

Solution of the emerging environmental crisis and continued evolution of consciousness will require that we shift into the Prosthetic-Synergistic Domain of consciousnes and that we seek harmony with the expansion of freedom and responsibility provided through the evolving brain.

The new type of brain may be designated as prosthetic-synergistic because of the likely accentuation of these two properties. Prosthesis will become much more important in the future because in the new domain people will tend to be linked into a world-wide communication network, thus leaving physical information processing prosthesis as the only major means of enhancing consciousness. Synergism will become important because the main function of the new brain, beyond increasing consciousness, will be to develop qualities of compassion and empathy which are necessary for individuals and institutions to function as nodes in a totally interconnected and interdependent network. The health of every node will depend upon the health of every other node. Self concept will be developed in terms of becoming a more effective node in the network. Ideational transformation will result from the synergistic focusing of diverse capabilities in united efforts to resolve problems. Be it noted that such synergistic organization is the basic implication of the "multidisciplinary approach" as contrasted to the isolated, individualistic, reductionism now characterizing most of basic science.

The reason for these changes lies in population growth. As mentioned earlier, if population growth continues without limit we will eventually reach a saturation point. Beyond this point additional individuals will interfere with the metabolism of information and retard further evolution of consciousness. If we allow population to increase to the limits possible, subject to the constraints of available resources, then the average individual would become less aware of less and less until most individuals have dropped below the level of consciousness requisite for initiating cultural evolution.

If zero population growth is the choice, the capacity of the individual will tend to remain constant also. There will be no further evolution of consciousness. Evolution will be terminated; for this corner of the universe it will be all over except for a continuous hedonistic traditionalism. Other animals have made this choice and persisted for millions of years. So might we, but only through our intent and actions can evolution continue.

If we elect to continue the evolutionary process of enlarging the consciousness of the individual, and the accompanying responsiveness and capacity for relating to the environment, then a necessary condition will be a compatible decline in population. But decline in population, though necessary for further increase in individual potentiality, does not of itself suffice. By the end of the current domain, roughly fifty years from now, it may be anticipated that the linkage of people and institutions into an effective world-wide network will have been accomplished. This will leave physical information processing prosthesis as the only major means for further enhancing consciousness. Elaboration and diversification of such prosthesis will become the main characteristic of the next domain of evolution, if we choose to initiate it.

In the remainder of his invited paper Calhoun concludes that a metascience, transcending traditional science, must be developed to solve the environmental crisis and to address the increasingly multidisciplinary nature of other problems. He believes that a new management strategy must be developed to manage this metascience. To develop a strategy, the many concepts which constitute conceptual space must be understood. Therefore, as a first step in developing such a strategy he defines conceptual space by identifying known concepts and specifying the relations between them.

## *The Systems Viewpoint of Human Behavior*

Earlier in this Chapter Hardin pointed out the difficulties arising from labeling a situation as a crisis and discusses difficulties arising from the need to communicate problems and solutions to a rapidly increasing population. Enlarging on these themes Bowen discusses the behavior of societies in crisis situations and discusses the emotional maturity of society. He begins by describing behavior from a systems viewpoint.

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A systems view of man represents a different order of thinking than is represented in our conventional theories. First I will present some of the major differences between systems and conventional thinking. It is difficult for man to shift from conventional toward systems thinking. I am not sure he can ever shift to systems thinking, when he is thinking about himself. I will present the key theoretical concepts that interlock to make up this total Family Systems Theory. This will be followed by some of the numerous relationship patterns in society that parallel family relationship patterns. Finally, there will be a summary of man's predictable emotional reactions to crisis situations, the difficulty in finding solutions that are not emotionally determined, the tendency of emotionally determined solutions to merely preserve the status quo, and ways emotionally determined solutions can intensify the problem. Systems thinking provides no magical answers, but it does provide a different way of conceptualizing human problems, it offers a more realistic evaluation of the difficulty in changing the basic patterns in any human dilemma, and it suggests ways to avoid some of the pitfalls of conventional thinking and to institute progress toward long-term goals.

## Background Assumptions and Hypotheses

The first of these assumptions was worked out early in the research. It came from previous study and experience and was based on the notion that emotional illness is deeper than a one generation product of parent-child relationships; that it has about the same incidence in different cultures with widely different child rearing practices, if there is allowance for the ways different cultures deal with emotionally impaired people; that there are suggestions it might even exist in wild animals; and it would be profitable to have this broad assumption in the background. The other assumptions were also defined as broadly as possible, but they were more directly related to early observations in the research. The earliest research models about relationships were based on systems thinking but there was not specific awareness of this at the time. As time passed, the term "systems" was spontaneously used to refer to the automatic predictable behavior between family members.

1. *That Emotional Illness Is Directly Related to the Biological Part of Man.* This was based on the assumption that man is more intimately related to the lower forms of life than is generally recognized, and that emotional illness is a dysfunction of that part of man which he shares with lower forms.

2. *That Emotional Illness Is a Multigenerational Process.* There were early experiences and observations to support this working general assumption. This was later defined in detail and incorporated as one of the theoretical concepts in the total theory. This postulated that the problem in the patient is a product of imperfections in the parents, and the parents a product of imperfections in the grandparents, continuing back for three or more generations, and that each generation was doing the best it could considering stresses and available resources. The most important function of this postulation was to help observers escape from the narrow limits of individual theory which blames parents for the child's problem, and to gain a more objective overall perspective.

3. *That There Is a Wide Discrepancy Between What Man Does and What He Says He Does.* The beginnings of this were based on early research observations. This was another guiding principle that permitted observers to gain some distance and begin to see some order to the multiplicity of messages and actions that are part of the hour-to-hour observations. The second year a member of the research team did a paper, "The Act Dialogue in an Intense Relationship" which told a story based on action alone, that appeared to have more validity than verbal dialogue.

4. *Structuring "Hard to Define" Concepts into Functional Facts.* This was part of an effort to find some structure and Fact in the shifting, subjective world of human experience. It is difficult enough to conceptualize subjectivity in dealing with one person. In a family relationship system it is far more complex. Over a period of time, we began developing a formula which helped to move more rapidly into systems thinking and which made research observations more objective and measureable. The incorporation of functional concepts into therapy has resulted in therapeutic results that are far superior to conventional therapy. For instance, one concept would say, "That man dreams is a scientific *fact*, but what he *dreams* is not necessarily a fact." The same formula was applied to a wide range of functional concepts, such as "That men *feels* (or *thinks*, or *talks*) is a scientific *fact*, but what he feels (or thinks or says) is not necessarily fact."

5. *Cause and Effect Thinking.* Man has been a *cause* and *effect* thinker since he first became a thinking being and he began to look for causes to explain events in his life. We can review the thinking of primitive man and be amused at the evil and malevolent forces blamed for his misfortunes, or we can review the history of recent centuries and chuckle at the errors in the assignment of blame that resulted from lack of scientific knowledge, while we smugly assure ourselves that new scientific breakthroughs and logical reasoning now enables us to assign accurate causes for most of man's problems.

## Limitations of Cause and Effect Thinking

Systems thinking, which this research has tried to implement in human relationships, is directed at getting beyond *cause* and *effect* thinking and into a systems view of the human phenomenon. In the course of trying to implement systems theory and systems therapy, we have encountered the intensity and rigidity of *cause* and *effect* thinking in the medical sciences and in all our social systems. Man is deeply fixed in *cause* and *effect* thinking in all areas that have to do with himself and society.

Systems thinking is not new to man. He first began to use it in theories of the universe, much later he started thinking systems in the natural sciences, and also in the physical sciences. There was a rapid increase in systems thinking with the beginning of the computer age, until now we hear about efforts to implement systems thinking in many new areas of the applied sciences.

The medical model has been one of the proven cornerstones of good medical practice. It is based on *cause* and *effect* thinking and the principles of careful examination, the establishment of etiology (cause), making an accurate diagnosis, and specific treatment directed at the etiology. The medical model has served medicine and society well for all diseases within the person of the patient.

The theory and practice of psychiatry also employs the medical model, and *cause* and *effect* thinking. The theory, based on the study of the individual, postulates an illness in the patient developed in relationship with the parents or other close family members, it requires a diagnosis, and treatment is directed to the patient. The model "blames" the parents for the illness, even though the psychiatrist may deny that he blames the parents, and the model excludes other family members from the treatment process.

And so, the medical model created a dilemma when applied to emotional (functional) illness. Family research was directed at trying to find an answer to this dilemma. The development of systems theory and therapy has been superior in treating emotional problems but it is conceptually and therapeutically out of step with medicine and conventional psychiatry. The medical centers in which a family orientation has been most successful are those in which conventional psychiatry has not been too strict in enforcing the medical model and family therapists have not tried to oversell their viewpoint.

## A Communication Model for Transmission of Emotional Reactions

Emotional reactiveness in a family, or other group that lives or works together, goes from one family member to another in a chain reaction pattern. The total pattern is similar to a communication system in which each person is "wired" or connected by radio, to all the other people with whom he has relationships. Each person then becomes a nodal point or a communication center through which single or multiple signals pass in rapid succession.

Different kinds of signals exist, and each with a wide spectrum of intensity and degree of importance. A more important set of variables has to do with the way each nodal point, or person, functions in the system. Each person is programmed from birth to serve a certain set of functions. Each "senses" what is required or expected, more from the way the system functions around him than from verbal messages stating he is free to function as he pleases. Each person, or nodal point, has varying degrees of ability for handling signals (native ability), styles for handling signals (personality characteristics), a narrow range of choice in rejecting or transmitting signals, and an intellectual awareness (intelligence) for understanding the operation of the system.

There is another important set of variables that have to do with the way the family unit functions together. Each person becomes aware of his dependence on all the other nodal points. To be remembered is that each nodal point is "wired" to the others by a two-way channel. There is a wide variety of subtle alliances for helping each other, refusing to help, or hurting the others. The larger unit can punish a single member, and a single member in a key position can hurt the whole unit.

Another predictable pattern is the placing of "blame" for failure to function (*cause* and *effect* thinking) and the pattern of either blaming the other or blaming self. Under tension, every person tends either to place the "blame" outside of self (blamer), or within self (self-blamer), or alternate between the two, which is the pattern of *cause* and *effect* thinking. If the head of the family unit is calm, the entire family unit can be calm and the communication system operates smoothly. When the head goes into panic and transmits panic signals, the others send back panic messages which further panics the head, in a mounting cycle of panic, with poor handling of messages, disorderly and conflicting messages, and increasing paralysis of functioning. Any unit can recover from periodic panic or overloads, but when the panic becomes chronic one or more of the individual units can collapse (become sick), and there are several variables for handling that. There is another set of very important variables having to do with the way the family unit is wired into other families and larger social systems, and into the total system of all society.

## *Conclusions*

This systems approach postulates the environmental problem as having been created by biological man (in contrast to intellectual man) as he has evolved, developed, and propagated, that man has permitted the environmental problem to develop so far he is beginning to threaten his own future existence, that the biological-instinctive-feeling oriented part of man will not provide consistent help in finding solutions, and that constructive solutions to the problem will depend on the highest functioning of intellectual man in directing total man toward solutions. A systems approach strives to view the environmental problem as a functional part of society's other problems, rather than separate from other problems.

From a systems standpoint, what are some of the things society might do to modify the environmental problem and what are some reasonable predictable outcomes of the various approaches? Society's most common approach would be emergency, feeling oriented, fragmented measures directed at a specific symptom. It could even go on to specific legislation "with teeth in it" to apprehend violators. This type of approach would be similar to the distraught family and its crisis oriented measures to relieve the symptom of the moment.

### **Emotional Functioning of Society**

This can lead to the delusion that the problem is solved, a complacency that permits him to continue what he was doing to add to the problem, and then the rude awakening with new and more serious crises, and a basic problem that grows worse. These are some of the characteristics of efforts at corrective measures that make the problem worse and worse. It is easy now to see corrective activity, most of which is good, which attacks a symptom here and another there, which leads people to believe they are working out a solution while the basic problem remains unchanged. The various "ecology" programs to limit the use of pesticides, to control air and water pollution, to recycle waste products, clean up litter, etc., are all positive, but any program directed at symptoms as they surface can well lead to missing more basic issues and a long term "making the problem worse."

Any approach to the environmental problem must take into account the current lower functioning level of society. Any issues that are settled by public debate and congressional action will automatically reflect the average level of society and emerge with emotionally determined corrective action. Society tends to elect public officials, from local level to congressional level, who reflect the average functioning of society. There are some notable exceptions but the majority represent the emotionally determined average of society. Whatever happens, any proposed solutions should come from the best brains and the highest levels of technical and emotional functioning in society who can lead and set an example. To expose the critical issues to the emotional average level of society would expose the whole program to a lower level of emotionally determined Cause and Effect thinking. Perhaps an agency similar to the Space Agency could accomplish the mission.

### Need for a More Differentiated Society

There may be some guidelines from the long term effort toward differentiation in a family. In the beginning, when symptoms are high, it might be indicated to use anxiety relieving measures, such as meetings with the entire family unit or with the parents, the heads of the unit, to re-establish communication and settle disharmony. If the goal is toward long term stability and the differentiation of self, this eventually becomes the effort of one person who can give primary attention to self. This involves the principle that all family members play a part in everything that goes on in the family. It is never possible to really change another person, but it is possible to change the part that self plays. The modification of self requires that person to be sure of self on all life principles that involve himself and his family, to have the courage to take action on his convictions, and to devote primary attention to becoming the most responsible possible person.

Most people operate on poorly defined principles and have never devoted much time to their own beliefs. There are repeated principles that are hard to clarify. At such moments of indecision, it is common for people to discuss issues with spouses or other close family members who use this opportunity to sell their own values, which, if accepted, modifies the self of the differentiating one toward a "family self." At such points, if one is to be successful at differentiation of a self, discussion should be with those emotionally removed from the family, or he could go to the literature, or go into isolation to work it through for himself. A person working toward responsibility in self is always aware of his responsibility to others. As he devotes primary energy to self, he automatically becomes more responsible toward others, and less irresponsibly over-involved with others. As the differentiating one moves toward more differentiation, the others go through the brief period of attacking, designed to re-establish the old level of togetherness. When the differentiating one is through his first nodal point, then another, and another, and other family members begin the same kind of effort. Such a family is a far more healthy organism with freedom from old regressive symptoms. The family is calm, with a new, more mature level of togetherness and a new ability to responsibly handle problems as they arise.

A more differentiated society would not have as serious an environmental problem as we now have. If society functioned on a higher level, we would have a higher percentage of people oriented to responsibility for self and others, and for the environment, and a lower percentage, focused on rights and force and on legal mechanisms to guarantee rights. A more differentiated society could take the present environmental problem and find better solutions than will be possible in our present less differentiated state.

The differentiation of self on a societal level would be hard to implement. In a family, differentiation begins with one responsible family member in a key position. When this person pulls up to a higher level of functioning, then another, and then others automatically do the same. This family, with each focused on the responsibility for self, is automatically more responsible for others. With each responsible for self, there is no longer the intense emotional triangles that impinge certain family members, nor a family projecting process in which the stronger family members improve their functional strength at the expense of the weak who become weaker.

In our society, the whole of the middle and upper classes of society spend a fair percentage of their time, energy, and money being concerned about and trying to be helpful to the less fortunate. The effort activates the family projection process and the well-to-do segment of society, through the projection process, further impairs the less fortunate. Man has a responsibility to those less fortunate. Responsible man fulfills such responsibilities automatically. If the most influential segment of society could work toward the differentiation of self, it would automatically spread through the less influential segments and really benefit the less fortunate segment and raise the functional level of all society. The powerful togetherness forces in society oppose any efforts at differentiation of self. The lower the level of differentiation, the harder it is to start a differentiating effort. The togetherness forces at the present are intense. However, any differentiation in any key person in society automatically rubs off on others. Anyone who moves in this direction benefits society.

### Remove Crisis Label from Environmental Issues

Finally, I think the word "crisis" should be removed from the term "environmental crisis" and replaced by a term implying a long term process. Our society is oriented to the use of Cause and Effect thinking and instituting crash solutions directed at symptoms which lull people into the belief the problem is solved. Man's disharmony with his environment is a long term evolutionary process and if it continues man may exterminate himself. The thesis here is that man is not going to change the environment enough to correct the disharmony, and that the ultimate change will require an order of change in man he is not yet able to contemplate.

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# 6

# GROWTH AND ECONOMICS

## *Summary*

If some economic growth is inevitable, then some economic change is also inevitable. If we wish to manage growth and also improve our quality of life, our economic concepts and philosophy must change. New economic concepts, their relationships to classical concepts, and implications for economic policy are discussed in this Chapter. The discussion is taken from the invited papers of Carl Madden and Chester Cooper.

Madden discusses classical economic concepts which, together with newly emerging thought, will influence economic policy. He also reviews changes in our culture and describes a global view shaping economic thought. By applying the concept of entropy to economics he concludes that waste accumulates faster than useful output but also concludes that the situation is not hopeless; zero economic growth need not be enforced to preserve the quality of the environment. He proposes the application of knowledge to create new concepts of wealth and more efficient use of energy as possible solutions to the economic entrophy trap.

Madden also states that economic growth, especially that which provides for social issues, necessitates change. He reviews the costs of such change and concludes that the costs can be borne. To implement change, business must be provided a profit motive and other incentives. Suggestions for providing these incentives are given and the concept of corporate social accounting is introduced. He also discusses the policy implications of economic change, outlimiting the elements of a government-business growth policy which could lead to an improved quality of life.

Cooper introduces a concept of "sustainable growth" defined as economic growth which provides sufficient discretionary income per capita to provide a desired quality of life without environmental degradation. He states that such growth requires a perception of stewardship or legacy by society so that resources are conserved and the environment is preserved for future generations. In discussing policy and planning he stresses the need for developing goals responsive to the needs of society and emphasizes the need for close coordination between the goal-setting process and the planning process. He believes that planning should be integrative, addressing social as well as economic and physical issues.

## *Classical Concepts of Economic Growth*

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Some economic growth is inevitable. Somewhere between the extremes of uncontrolled massive growth and zero growth lies the growth and change we require. In the next decades, hoever, the character of our growth must change. Ways to minimize environmental degradation and to provide a better quality of life for a greater portion of our population must be found.

If economic changes are to be brought about, new economic concepts will have to be developed. However, the classical economic concepts will continue to be valid. Economic growth will occur within the existing framework and will be accomplished over a long time. The classical concepts, within which the new policies must be made, are explained by Madden.

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Madden points out that change and economic growth are inextricably linked. Economic growth does not refer merely to the increase in the number of physical and tangible objects. It is a more complicated concept, rooted in human values, and still subject to advances in understanding.

At times economists have refered to physical economic growth in "real" output in ways suggesting their oversight or ignorance of the laws of biology and physics. Without doubt, the growth in numbers of any specific form of economic product within any given space is subject to the biological and physical laws of retardation.

The confusion concerning economic growth arises from efforts to depict "extensive" economic growth in physical terms, as when economic growth has encompassed the structural growth of an economy, the extension of geographic frontiers —as in the economic history of the United States, the development of a steel industry in a backward nation, or the doubling of electric capacity in an advanced economy. Economic growth, as we have known it, does have a physical counterpart in the increase in the number of physical objects of given types resulting from the growth of an industry or firm. But economic growth is more.

### Economic Growth Means Growth in Value

Economic growth is growth in value. This can be seen by examining basic concepts. In economic theory, a commodity is not a physical object only. A commodity is a relationship between three entities: a producer (seller), a physical object or person, and a user (buyer). The market value of a commodity is the discounted present value of the expected (annual) future services that flow from the physical object or person. Wealth is defined as the stock of commodities. Thus, wealth is the sum of the present discounted (market) value of the expected future services that flow from the totality of commodities.

For a nation, economic growth is measured by an increase in gross national product, more precisely by an increase in net national product (which allows for use of capital in the growth process).

Gross and net national product are measures of value, not of physical size or physical numbers of objects. GNP is defined as the total market or exchange value of the final output of goods and services by the nation's economy, measured in current monetary value. "Real," or constant dollar (pound, mark, franc, etc.) GNP is not a measure of physical size of output, but a relative measure of value corrected for changes in the value of money measured from a base period.

Economic growth, as distinct from growth in simple physical output terms (i.e., the growth in the number of physical objects made by man), is an important and evolving concept. Economic growth provides a measure, admittedly limited to market or exchange value (hence, excluding non-market wealth creation), of the values hence satisfaction attached by people to the increase in wealth.

The concept of wealth, as the stock of commodities, is also an important and evolving concept. It is important to notice that wealth, as representing the present discounted value of expected future services flowing from objects or people, does not refer to the past, but to the future. It is important to notice that all measures of economic value, and hence of economic growth, are anthropomorphic. That is, these measures of value are meaningful only in relationship to human purposes, judgments, and evaluations. Indeed, their meaning is even more restricted by conventional reference to market or exchange value, excluding all other forms of human value.

In measuring economic growth, it is well known that GNP measures the total value of output unreliably, but from period to period GNP measures reasonably well the change in the value of output. GNP, as mentioned, includes the cost of maintaining or replacing an economy's productive capacity of plant and equipment (but not human skills). National income, a measure of the income attributable to the agents of production, excludes these costs and is a better measure of the net increase in the value of output available to firms and people.

**Economic Growth Means Growth in Productivity**

Economic growth also may be viewed in productivity terms. The concept of productivity is not widely grasped with any accuracy. The concept is an analogy to physical efficiency, but it is not the same as physical efficiency. Physical efficiency is defined as the ratio of *useful* output to *total* input. The concept is anthropomorphic; someone has to define useful. Physical efficiency also is subject to the laws of thermodynamics: energy is conserved; entropy increases (of which more later).

Productivity refers to economic output as a ratio to total input. Because of the difficulty in measuring accurately the inputs of capital and natural resources to the processes of wealth creation, productivity—as a convenience—is measured most often in labor input terms. Hence, productivity is most often expressed as "output-per manhour." The difficulty with measuring productivity in output per manhour terms is the tendency created thereby for false inferences from the measure to the conclusion that productivity gains are attributable to improvements in the productivity of labor itself. In fact, gains in productivity occur in an exceedingly roundabout process, ranging from cultural behavior (in religious, social, political beliefs, habits, and institutions), through basic science and educational policy, to the nature of economic institutions and incentives (the patent system, tax incentives for investment, and the like). The point about the origin and configuration of productivity gains is important to understanding who pays for change and how.

Economic growth, when viewed in productivity terms, is expressed as the increase in GNP, or in national income, per worker. Or, it may be stated on a per capita basis if we wish to consider output or income in relation to total population. Here, too, the emphasis is on the increase in value terms. At bottom, then, economic growth implies growth in 1) the total value of the nation's output, 2) consumption per capita, and 3) the level of living standards that the population enjoys.

## Economic Growth Means Change

Economic growth is inseparable from change, and growth is accompanied by change, although not all change is growth. The conditions under which growth occurs impose change. "Creative Destruction" is the term employed by the late Joseph A. Schumpeter to characterize the method or process of economic change in the enterprise system (1). Schumpeter described the Creative Destruction process this way:

> "The opening up of new markets, foreign or domestic, and the organizational development of the craft shop and factory to such concerns as United States Steel illustrate the same process of industrial mutation—if I may use that biological term—that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one."

Change and growth come about when a new product or service invades an existing market. As, in that market, consumers shift their preference from the old to the new commodity, the capital used to produce the old commodity is gradually devaluated—destroyed—as profits in its sale decline.

Capital is attracted to the new commodity by its high rates of profit. Growth comes about as the result of innovation derived from new invention. Together they render obsolete the plant and equipment, and even the organization, devoted to producing existing commodities; that is, eventually they reduce its value to salvage.

In an enterprise economy, competition in the marketplace serves a social function analogous to the mechanism of survival in the evolutionary process of biology. The test of success in the marketplace is nothing less than survival, and the reward of survival for a given commodity may be growth. In the market, competition is impersonal but pervasive, and advances in technology of worldwide transport and communication increase and intensify the worldwide forces of competition if not limited by restraints on trade and investment among nations.

Competition in a nation exists not only between products or services of a given type but also between geographic regions and geographically separated urban regions. In a political system such as the United States, which provides freedom for the geographic flow of information, ideas, money capital, people, and jobs within a broad geographic area, resources tend to flow to those places where they yield the most human satisfaction. The process operates in small, marginal movements which, however, when cumulated over time periods, reveal very large changes.

This principle, not at all well understood, helps explain migration patterns. For example, at present stages of affluence and technical means of transport, the United States is becoming more (1) urbanized, (2) metropolitanized, (3) suburbanized, and (4) coastalized. Urban movement is explained by greater economic opportunity, even for poor blacks, in cities than on farms or in the rural countryside. Studies of the Urban Institute show that poor blacks, drawn from the 1967 OEO sample of the poor, who migrate to urban areas, within five years experience increases of $2,000 in real income over non-migrants in the sample.

Economic growth is thus an evolutionary process in which new technology is tested for its survival value in terms of superior ability to provide human satisfaction. It is important to understand that in a market economy, growth is impelled by the organization of firms in markets. The firm provides a means of comparing private benefits, as measured by revenues of firms, to costs of production, or private resource costs, including ancillary taxation costs to firms of public goods necessary to production, such as the overhead costs of urban life. Private firms are driven to reduce costs through the motivation of profit in the face of competition by other producers.

It is also important to understand that the social function of profit is to impel producers to provide the goods and services that people want and have the ability to buy, at reasonable prices, without being forced to do so. The profit system gives us (1) a method of organizing economic activity that encourages enterprise, (2) a way to stimulate risk-taking and innovation, (3) a way to allocate the skills of people, our natural resources, and our know-how to purposes consumers think are most useful, and (4) a way to make heads of firms, whether they want to or not, always try to cut costs and make resources go as far as possible consistent with consumer tastes and income.

Finally, it is important to understand that economic processes supplant one another as do biological species, according to their survival value. Survival value among economic processes is determined by relative productivity, in relation to consumer values expressed in purchasing habits and preferences. The result is that the economic growth process is evolutionary with respect to rising productivity, in turn related to physical efficiency. The marketplace applies the test of economic productivity to the many competing technologies which may add to physical efficiency. Thus, economic evolution is directly and profoundly related, in market economics, to the evolution of scientific knowledge and technical proficiency. And it is constrained by definitions and content of cultural concepts such as wealth, income, productivity, and cost. These concepts have changed their meaning during the course of industrial evolution and the advance of knowledge. We can expect that in the future their meaning and content will continue to change in response to broadened human understanding.

## Economic Growth Needs A Cultural Framework

GNP, the value of output, in the United States grew at a rate of 3.3 per cent a year during the 1929-1969 period, or 2.0 per cent a year on a per capita basis, both figures adjusted for price changes.

What is the mechanism by which economic growth occurs in our society? We must realize that the conditions favoring economic growth develop in a framework of social beliefs, customs, and institutions. Economic life must not be rigidly constricted by custom or tradition; rather, it must emphasize individual creativeness and self-reliance. It must foster the idea that people are to be esteemed for what they do rather than for their family's social position. Work and material success must be admired. A degree of responsible competition among people must be favored. And opportunities for individual economic betterment should be widely available.

The climate of thought must favor a reasoned approach to problems. People must be willing to give up digging sticks for plows, horses for cars, sulfur drugs for penicillin, through faith in the validity of material advance, or in the validity of the principle that applied knowledge improves the quality of life. The scientific spirit, the experimental attitude, and respect for universal physical and biological pattern and configuration stimulate technological progress. Supersitition, witchcraft, fatalism, elements which have dominated many cultures, are enemies of economic growth.

There must be a unifying and reasonably stable government to maintain law and order, to protect both political and economic rights, to enforce contracts, and in general to establish, maintain, and alter rules of the economic game. Private investors cannot make investment decisions which look to the future unless life is in some degree orderly and predictable. Producers cannot market complex services stemming from technological advance unless there exists widespread understanding of the beneficent purposes of such activity.

Managerial and technological talents must be developed by society and available for employment. The educational system, and ancillary cultural institutions of mass media, entertainment, journalism, the church, the university must share to some degree a common "public philosophy" concerning ultimate human values. There must be people who can and do organize, launch, and guide new organizations and new ways of doing things.

There must be investment in transportation and communication networks. People who are isolated may not engage in industrial or regional specialization. Also, there must be institutions of banking and the capital market to provide a monetary medium for trading, for saving, and providing throughout the geographic reaches of an economy many competitive channels through which savings can move to investors.

**Government Fosters Economic Growth**

Government and enterprise have to cooperate to achieve economic growth. In the specific processes of the market, business leaders in the United States (each firm acting independently of others) provide the primary leadership for economic growth. In pursuit of profit, adventure, prestige, power, and creative satisfaction, business leadership struggles to survive in the marketplace according to existing customs and rules at a given time. Management decisions to build more plants, to do more research, to expand employment, to re-organize firms, to adopt new marketing techniques, to change processes, to introduce new products or services, to borrow more funds are all market-conditioned and geared to short run (ten-year, at most) planning horizons. Investment analysts follow corporate results in profits on a year-to-year, or even shorter basis, and in making investment decisions. The long run is heavily discounted as against immediate performance.

Government in the United States, however, has made powerful long-run contributions to the conditions of economic growth. Perhaps the most powerful contributions have aimed at designing framework goals within which economic development could flourish. Provision of personal freedom and mobility of resources, private property, and limited federal government is a keystone concontribution of government. The constitutional rights provide mobility of key economic elements —ideas, information, money, goods, jobs, people. The public education system, beginning with the Northwest Ordinance of 1789, used public capital (land) to finance human capital investment (educated people). In the early nineteenth century, investment in "inland improvements" with government funds, later use of public land to spur land settlement (Homestead Acts), a *laissez-faire* policy of bank and corporate chartering, all stimulated economic development. In the mid-nineteenth century and beyond, government devised powerful means of transfering throughout all the states knowledge of science and technology to farming and allied arts through the Morrill Act of 1862, setting up land grant colleges, and through later legislation, creation of the Federal Reserve System in 1913 gave the country a central banking system to check recurrent money panics. And so on, until the Employment Act of 1946 established federal responsibility for high employment levels.

Government also directly participates in economic growth. It has been and is a major investor in research and development. In transportation, Government helped finance canals and railroads, and today it continues to build highways and to subsidize aviation and shipping. It invests in labor force improvement through public education, contributes greatly to college education by creating and improving state institutions for technical and higher education, by awarding research grants to universities, and by making loans and giving scholarships to students.

Government promotes growth indirectly through its international economic policies, such as tariffs in the nineteenth century and foreign aid since World War II, or as in the space effort that has produced technological fallout for industry as well as vast new public understanding ("Spaceship Earth") of natural laws and of our economic and technological capabilities (If man can go to the moon, why can't he . . . .).

Government also promotes growth in the U.S. by its policies of fostering competition. Beginning in the nineteenth century with the New York law of 1811, states began passing general incorporation laws to enfranchise corporations. By 1875, such general laws of incorporation, including provisions to protect creditors, were common. By as early as 1865, the modern conception of the corporation had emerged, holding that the rights of creditors and owners as well as technical operation of the business were subject to the discretion of management, acting as trustees for the owners.

Government fosters competition also by social policy respecting monopoly. If a corporation has a monopoly of a desired good, it can hold off the market a portion of the supply, force the price up, and make "monopoly" profits. Our social policy deals with monopoly in several ways. If the monopoly is "natural" because technology is too expensive to duplicate, we regulate corporations, as in utilities, telephone, television, air transportation, banking, natural gas, and other industries. If U.S. corporations engage in practices that restrain trade or tend toward monopoly, they are subject to suit by the U.S. government for violation of antitrust laws.

Corporations are also subject to a variety of regulations concerning their standard of behavior in relation to public necessity or convenience. These regulations, in effect, change the definition of cost, productivity, or revenue for regulated corporations, adding social to private costs or reducing revenue (which amounts to increasing cost) by restricting behavior. Such regulations relate to product purity, conditions of safety, or protection of the environment.

## Science and Technology Stimulate Economic Growth

The basic economic factor causing economic growth is investment, but productivity-improving investment is most often based on advances in science and technology. A distinction should be made between labor-saving investment, as improving the internal combustion engine, and industry-creating investment, as creation of the electronic computer industry. Science and technology contribute to both processes. They do so by improving the physical efficiency of an existing process (making cars) or by an invention or discovery creating a new economic process (discovering the logic of computers, inventing the computer as an application of the logic).

In the broad sweep of industrial history, science and technology have interacted in creating a rising spiral of efficiency in processes, leading to productivity gains in the economy. Science and technology make possible waves of innovation in the economy. An innovation is something new, in art, drama, commerce, industry, finance, or government. An economic innovation is not the same as an invention. The inventor is an individual gifted in translating technical knowledge into a new technique or product; inventors tell us they are rebels against fixed attitudes in a technical area of life. An innovation occurs when some person or firm develops inventions (either social, economic, or technical) into workable productive processes. Innovation, however, traces out in history the forward march of science and technology.

The scientific revolution, which has gained momentum since World War II, promises to speed the evolution of economic processes throughout the world. This broad-scale revolution of knowledge not only generates new products and services; it creates also a new perception of the relationship of ecology to economics. This means that the scientific revolution is not a typical wave of innovation. Rather, the scientific revolution creates a time of broad social change; it fits Hegel's tenet that gradual quantitative change can ultimately burst into a qualitative revolution. Earlier, the three stages of the industrial revolution created waves of economic innovation, resulting in social change. The new knowledge of the scientific revolution demands social innovation as a pre-requisite to economic change.

## Growth Requires Saving and Investment

Economic growth results from the process of saving and investing. Saving means not consuming. Investing means spending (or allocating resources) for goods and services other than for consumption. Saving means withholding resources from consumption; investing means using the resources for non-consumption purposes i.e., to increase or improve the means of production.

Savings decisions and investment decisions in our economy are made by two different groups which, though some members in the groups may be the same, have to be linked by an institutional mechanism —the capital and credit markets. Savers include individuals, families, business firms, financial institutions, and governmental units. Investors include individuals, business firms, and financial institutions. Obviously, for example, families are "on both sides of the market" in that they may be both savers and investors. This is also true of other participants in the capital and credit markets.

These markets work by linking together in a nationwide network of voluntary interfacing between institutions of the market, the countless decisions to save and funneling the savings into financial institutions. Decisions by investors, lenders, managers of financial institutions —such as insurance companies, pension funds, mutual funds —determine the uses to which savings will be put.

Stock exchanges provide no new savings or investment but represent means for shifting ownership or creditor rights through trading of equity shares or fixed-income securities. But in the credit and capital markets and within corporations (in part) new savings flow to higher priority investments. These higher priority investments provide the productivity gains, an increase in the value of output per worker or per capita, that are translated into economic growth.

## Business Runs on Profits

Every one knows that the corporation is a device for starting and running a business. Businesses create economic growth. How do they do it? Businesses produce, buy and sell, trade, or perform services in the marketplace, motivated by profit. The public, according to polls, believes manufacturing business makes 28 per cent profit after taxes compared to the correct figure (1971) of 5 per cent. For all financial corporations, the figure for profit rates on sales after taxes is only 2.3%. For the average wholesaler or retailer, the figure is 1.5%. Communications firms have the highest average, 6.2%, but these firms, many of which are government regulated, use far more capital equipment per sales dollar than most industries (they are "capital-intensive"), and in part they must use after-tax profits to buy it.

Modern corporations, then, organize and carry on trade and production to operate on a profit margin averaging less than a nickel on a dollar of sales after taxes. Owners of corporations, that is, shareholders, who invest in equity shares, may make gains resulting not only from profits (dividend income) but also capital gains (a rise in the market value of the assets behind the shares owned). "Growth" companies pay out small dividends, but owners risk savings in them to get "capital gains."

The profit system puts a premium on people who can do things other people want done. It gives people opportunity by and large based on what they can do, regardless of circumstances of birth (excepting discrimination —defacto —as in other leading institutions of church, labor union, university, and government, against black and female minorities).

Business firms, operating under the profit motive and facing competition, respond quickly and flexibly to changes in consumer tastes and technology. Although television was invented in the 1920's, years were required to perfect its mass production. But, through competition, mass production from 1947 to about 1970 placed black and white television sets in more than 90 per cent of United States homes. When people began to "eat out" more, franchised fast-service restaurants learned to limit menus, rigidly control time of preparation, cut costs through self-service, locate stores conveniently, and buy large quantities with precision, timing and skill. These are only two of thousands of examples, taken for granted in a market economy, of how business firms respond flexibly to consumer tastes and technology.

It is important to understand that, by and large, individual existing firms, whether they want to change or not, are impelled to change by competition. To an existing firm, sudden change devaluates its existing capital. But, if it does not change, the value of its assets, and the value of ownership rights to them suffer capital losses. Individual firms are free to change or not change, but profit is a powerful lash and a powerful reward.

Now, naturally, the larger in scope or substance is a change in technology or consumer tastes, the longer it takes for business to respond. For example, a major change in technology is resisted by firms whose present capital would be rendered less valuable. This is the reason Schumpeter spoke of innovation as "invading a market." This, too, is the philosophy behind the patent system, which gives an inventor a 17-year monopoly but publishes the design for others to learn from.

However, the market system and the profit motive spread the risk of the destruction of capital that results from economic growth. If a large firm or industry is "invaded" by an innovation, the market allows time for adjustment, but competition in the market spurs adjustment. There is no central direction, however. And the risk is spread not only over time, but as between management, workers, and stockholders, suppliers and bankers, and others related to the firm or industry—*all* of whom are free to make their own adjustments to developments.

Keep in mind, however, that major firms, faced with the invasion of an innovation, are reluctant to change in a way that devalues existing capital. Indeed, invasion by an innovation is analogous to a struggle between species, and managers of existing firms may choose to resist rather than risk the new. What's more, business managers have to keep in mind the *real* changes in technology and taste, not such changes advocated by inventors or students of taste. As a result, managers of existing firms may be cautious simply because of past success, and this is why the possibility should always be kept open for new entry into an industry facing competition. Existing firms seldom invest in capital-devaluating new technology until it is thoroughly market tested. And, it may be good management policy for dominant firms to let some other firm pay the costs of market-testing, and to move only when results are unmistakable.

Even with such a proviso, however, the dynamic United States economy in the past, swept by vast waves of innovation, has been no great friend of the industrial status quo. One great institutional innovation of the enterprise economy is bankruptcy. Bankruptcy gives a way of getting rid of unwanted institutions. In a highly developed society experiencing change, getting rid of unwanted institutions, those whose value is declining is a critical task. Indeed, perhaps the time is not far off to create, by analogy to corporate bankruptcy, a concept and means for instituting "social bankruptcy" for non-profit institutions or government programs of low priority.

Milton Friedman (2) has explained the advantage of the enterprise system in changing the *status quo*.

> "An unrecognized virture of the market vs. political arrangement is precisely that it is far less subject to the tyranny of the status quo. It is only necessary for one individual to see how he can benefit from changing the status quo for him to start to do so. In a truly free market he does not have to get permission from anyone . . . Contrast this with

the political process. To adopt some measure requires first persuading a majority before the measure can be tried. It is hard to start small, and once started, to fail. That is why governmental intervention is at once so rigid and unstable."

## Limits to Economic Growth

Do we have to stop economic growth in order for mankind as a species to survive on earth? Will the earth's interlocking resources be unable to support present rates of economic and population growth much beyond the year 2100, if that long, even with advanced technology? This is the basic problem facing mankind, in the opinion of Jay W. Forrester of MIT and his colleagues Donella H. Meadows, Dennis L. Meadows, Jorgen Randers and William H. Behrens III, who in 1972 published *The Limits To Growth*, as a report of the Club of Rome's Project on the Predicament of Mankind (3).

The "Zero Economic Growth" movement is the extreme form of the proposition that major emphasis should be placed on quality as against quantity of output. Proponents of this doctrine expound the thesis that we are now about a generation from the point of no return in overusing natural resources.

The Club of Rome comprises some eighty members, including scientists, humanists, economists, educators, civil servants; members are representatives of a wide variety of cultural and value systems, none of them involved in current political decisions, nor has the Club as a whole any ideological, political or national commitments. They share the common conviction that the problems facing mankind are of such complexity and interrelationship that traditional policies and institutions are no longer able to cope with them. Members of the Club of Rome point out that the club is not to be identified with the work of Forrester and colleagues but probably would endorse its main conclusions.

The project tried, through a set of mathematical models (the method is called "systems dynamics"), to simulate the world economy, and, by computing values of the model through 100 or more years of time, to trace out the dynamics of the system. The major model asked what were the interrelations between global population growth, pollution, food production, natural resources depletion, and economic development, stated in quantifiable terms of rates of change and absolute levels.

The research explores the effects of the interaction of the growth modes of these variables, which mutually influence and often reinforce one another. It provides, in effect, and for the first time, a panoramic view of the world's working, that could never have been obtained by making separate analyses. It is, therefore, a description of present dynamic situations and outcomes; it is not intended to indulge in predictions; it is explorative. And if not even predictive, it is surely not prescriptive.

Complex systems are sometimes counter-intuitive. The modern complex economy is beset by information feedback. Our dependence on the automobile is growing through feedback effects on population distribution. That is, the more cars and roads we have, the more people are enabled to live in suburbs, but the more people are living in suburbs, the more cars and roads we need. Or, people in cities live in poverty, so we build low rent housing for the poor, so more poor people move into the city, creating an oversupply of the poor for existing jobs, and thus poverty in the city increases.

## *New Concepts of Economic Growth*

Many studies take our present cultural norms of "industrialism" as given. They describe the dynamics of rising world population and spreading industrialism, to show that limits exist on the growth of world population, expressed as depletion of natural resources, mounting environmental damage, or food shortages. Much evidence now suggests that the era of industrialism is indeed drawing to a close.

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If we are entering a new economic era, our economic concepts will evolve. In this Section Madden reviews some of the features of new economics which must be implemented to improve the quality of the environment and the quality of life.

He discusses cultural changes and a new global view in which the whole is seen as more than just the sum of its parts and man is seen to be closely interdependent with his environment. Madden applies the concept of entropy to economics, concluding that with our present technology, waste accumulates faster than useful output as the economy grows. He discusses whether we can find ways to retard this economic entropy; the proponents of Zero Economic Growth contend these is no way to pile up output without being buried by waste. He discusses two strategies for overcoming economic entropy: more efficient use of energy and application of knowledge to develop new concepts of wealth, new principles for selecting economic processes and formulation of new economic growth policies.

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### **Cultural Changes**

The earlier waves of innovation created by economic growth harnessed to productivity-increasing science and technology changed the culture of industrial societies. These economic processes have been evolving; that is, they have changed our society and its values, creating at each stage a future different from the past. A moment's reflection brings up countless examples of cultural change created by economic growth.

Now, the scientific revolution presents us with a culture crisis. The search for improving the quality of life, at its extreme proposing Zero Economic and Population Growth, is directed toward how to abandon culture of the past and to create new culture —a more livable environment. What is meant here by culture is the definition of anthoropologists who, in the nineteenth century, studied the nonbiological extensions of human beings that allow them to achieve more effective interaction with their environment. Culture refers to all the things and devices, including nonmaterial things such as myths, beliefs, and stories, that human groups use to enhance, protect, or express themselves. Culture allows the human species to survive in the evolutionary process without having to accomplish biological specialization.

If we do not control our culture in the evolutionary advance of mankind, it will devour us. Through the ages, man has controlled his culture in order to survive. He has adapted it to conditions. Ours is an age when the existing culture is strained by new knowledge that conflicts with our beliefs and customs. The explosion of new knowledge is not the same order of importance as the earlier waves of innovation, and they were powerful enough in changing our culture. It is epochal in scope, ranking with the Renaissance. When a culture is put under strain, its alternatives are few. One alternative is that population is checked. This has happened before to other cultures that did not adapt. A second alternative is that the culture is fragmented by internal dissension or external domination. The third alternative, and by far the more consistent with survival, is the invention of new culture. In the long history of mankind, all evidence favors adaptation.

## The New Culture Changes Our World View

Epochal changes in mankind's history stem from new knowledge that is so general, powerful, and persuasive that it invades the predominant "view of reality" or "world-view", the set of assumptions, beliefs, and mental habits that shape our perception of reality. We find ourselves at such a hinge of human history, where the old culture at almost every turn clashes with the new.

What is the old culture, where did it come from? As Peter Drucker (4) points out, since Descartes, we have exercised 300 years of intellectual habit. Rene Descartes, the French philosopher and mathematician, more than anyone else —more than even Galileo, or Calvin, or Hobbes, or Locke, or Rousseau, more than Newton—has determined the scope of our perception, our basic concept of what is rational, what is plausible, "common sense."

Descartes made two magnificent contributions that have impelled us for 300 years. First, he gave us our basic axiom about the nature of the universe, that is, the nature of the order in the universe. It is the axiom, "The whole is the result of its parts."

Second, Descartes invented the method to make his axiom effective in probing nature and organizing knowledge. His mathematics established a universal quantitative logic. We have relied on this universal logic to determine relationships between concepts, and it has been capable of serving as universal symbol and universal language.

Descartes' formulation created modern scientific analysis and the modern specialized university, army, and business organization. It now eventuates in a maddening confusion of tongues among various branches of knowledge. It makes easy the growth of delimited bureaucracy. It stultifies perception of any aspects of reality except analytical.

The characteristics of our modern disciplines are incompatible with Descartes. Every one of them has moved from cause to pattern and configuration. They are concepts of a whole, of an organism or an institution or a process that can only be understood as a whole, as a pattern, as a configuration.

The contrast is sharp between the two world views. First, the basic axiom is that the whole is more than, different from, the sum of its parts; whole and parts are interacting. Second, man may not stand, as it were, outside nature, analyzing nature apart from himself. Cartesian thought led to control over nature —the promethean myth —as man separated his mind from his body, following Descarte's dictum, "I think; therefore, I am." And finally, the new world view is that of irreversible process, not reversible action within abstract time and space.

The three characteristics of the new era may be called holism, naturalism, immanentism. We are about to embark on a strategy of knowledge which sees processes holistically —sees the patterns and configurations that determine the flow of events within processes. The guiding philosophy of the new culture also includes a new naturalism, which affirms that man is a part of nature, of the universe, that itself is always in the process of becoming. And, third, a new immanentism sees that the system, organism, or situation that is in process of evolving is determined not from outside but from within.

The debate over limits to growth signifies that a profound re-examination is taking place in man's view of his relationship to nature, to his institutions, and to his fellow man. Ours is a society which, until recently, rarely challenged the virtue of continued economic growth, per se. But today's concern about the quality of life and about the impact of economic and population growth on human survival is the outcome of the very scientific revolution that has generated much of today's industrial capacities. It is the very new knowledge itself which challenges old viewpoints.

As a result, our society is at a point of profound change, from a society in which production of goods was of primary concern to one guided by a new growth policy, dominated more by services and by the creation and use of new knowledge. The present is a period of marked social change, one aspect of which is the search for a new policy of balanced growth to guide that change. Such a new policy of balanced growth will have profound effects in changing present institutions. These institutions themselves are required now to undergo evolution, in order to re-orient themselves toward the tasks appropriate for a society reaching for a new level of performance. The range of criteria by which to judge institutional performance will be broader in scope and longer in time perspective. To determine these criteria is a major cultural task of our times.

## Entropy In The Economic Process

In terms of economic theory and policy, the concern of environmentalists that eventuates in doctrines of Zero Economic Growth and Zero Population Growth raises the issue of the relationship of entropy to economics. As Nicholas Georgescu-Roegen argues, the issue is fundamental (5). The issue addresses the meaning of the flow and irrevocability of time, the characteristics of life, the nature of causality in biological and social science, and the theory of economic development.

To understand the impact of the idea of entropy, consider first the concept of time in economics. The concept is drawn directly from classical mechanics, in turn derived from the mathematics of Descartes. The Cartesian, reference-axis depiction of time assumes that time intervals are cardinally measurable. That is, it is assumed that qualitative differences in time periods can be ignored in measuring time intervals. The implication of assuming that time is cardinally measureable is that time is also reversible. Economists, in employing the mathematics of Descartes, unwittingly assume that time is reversible. Economic theory studies the allocation of resources among competing ends, assuming that tastes, technology, and resources are given. In analyzing the relationships between revenues and costs, economists pay little or no regard to the impact of the economic process itself on tastes, technology, or the availability of resources. These aspects of the economic processes are considered as "externalities," that is, as costs or benefits which are "external" to the theory of the firm or market. Unwittingly, economists have failed to realize that waste and pollution are not "external" to the economic process, but flow from the irrevocable nature of time.

In the classical theory of thermodynamics physicists have had to face the irrevocable character of time. The first law of thermodynamics holds that throughout the flow of time, in any closed energy system, energy is conserved; that is, total energy remains constant and may be transformed but not created or destroyed. The second law of thermodynamics involves entropy. Broadly, entropy measures the rate at which free or latent energy, available to do work, becomes bound energy no longer able to do work. The Entropy Law, simply stated, holds that the entropy of energy systems increases constantly and irrevocably. The Entropy Law means that waste and pollution (i.e., bound energy unavailable to do work) increase inevitably in the flow of energy in any closed energy system operating through dynamic, irreversible time. The laws of thermodynamics clearly apply to economic processes just as they also apply to any other processes involving energy flows. Indeed, other things being equal, waste and pollution pile up at a faster rate than output grows.

## The Accumulation of Waste

To grasp, therefore, the implications of this new insight into the nature of the economic process, and to arrange policy measures consistent with its significance, is a part of the new world-view through which alternative growth processes, and questions such as who pays for growth and how, must be seen. To begin to see them, it may be helpful to examine the Zero Economic Growth and Zero Population Growth arguments from the perspective of the earlier Malthusian theory.

Malthus (1766-1834) focused his entire social and economic thought on his ideas about population. He argued that population when unchecked grows at a rate so much faster than it is possible to increase the supply of food, that population is constantly pressing on the means of subsistence. What Malthus overlooked is easy to see by hindsight. It is the growth of productivity in the last century and a half. To put the point another way, we know that in physical terms, output is a function of inputs, in any production process. We call the relation "the production function." Malthus thought the production function would stay stable, that the relation itself of inputs to output would not change.

But the production function did not stay fixed and invariant. By ever-increasing productivity in the Western World, we have shifted the production function to get each year on average more output for a given input of resources. So, in the industrial countries, both our population and our standard of living have risen, and we have so far escaped "the Malthusian trap."

The present-day Zero Economic Growth school may be called "neo-Malthusian." To see why, we need to focus on the waste created by production, which, as we have seen, piles up at a faster rate than useful output does. To see how, we may consider a twentieth-century discovery of the relation Eugene Zubrow of the University of Colorado calls, not only aptly but accurately, "the crud function."

A crud is defined as a stockpile of noods, and a nood is defined as a negative good. An economic good is the physical embodiment of a stream of services which is scarce and useful. A nood is the physical embodiment of something that must be harmful—and so, results in disutility. Also, it must be relatively abundant. And crud is, as we have seen, a function of output, just as output in turn is a function of input. Crud mounts with output, but at a faster, exponential, pace. The Zero Economic Growth thesis is that there is no way to keep piling up output without being buried in mountains of crud.

### Strategies for Retarding Entropy

The issue posed by the Zero Economic Growth thesis is whether mankind can systematically shift the crud function, as it earlier has shifted the production function. We need to get less crud for a given output. But how? To answer this question is to lay the groundwork for understanding generally the requirements of alternative growth policies consistent with the morality of science seen as natural philosophy. And, by the same token, to answer this question provides a rationale for policies involving trade-offs of distributing the benefits and costs of the economic process with equity and clarity, and therefore, with political legitimacy.

The escape from "the entropy trap" posed by the Zero Economic Growth thesis requires a step forward in cultural evolution to full recognition of the meaning to the economic process of the laws of thermodynamics. It is not technology which is to come to mankind's rescue. Already, as we have seen earlier, market economies provide a survival test of alternative technologies. What may come to our rescue is therefore not "more techology." Rather, it is the guideposts provided by the scientific revolution itself. Our knowledge, and its implied morality, not technology, provide the choice.

By analogy to biological evolution, industrial society has, in general, only two strategies of escape from the entropy trap:

1. deliver more useful energy to our systems and substitute energy for matter in processes, or
2. bring to bear more useful information in social and economic processes.

These two abstract and interrelated strategies—not now fully grasped—offer the rationale for designing policy consistent with balanced economic growth. They suggest that the Zero Economic Growth thesis, though certainly as valuable as the earlier Malthusian theory, does not means necessarily an end to the growth of wealth. Far from it. The Zero Economic Growth thesis has, as its highly significant positive value, the virtue of challenging the world-view of the industrial society which has hitherto ignored the crucial role of environmental balance and resource depletion. In its industrial stage, mankind has learned to "get more from the same." Now, say the Zero Economic Growth advocates, he must learn to "accept the same, but from less." It is the thesis of the present argument that the Zero Economic Growth thesis misstates the alternative. The alternative is, as Buckminster Fuller has argued, "to get *more* from less." That is, the view held here is that wealth can positively increase from economizing much more severely on material inputs to the economic process than before.

## Using Energy to Retard Entropy

The first strategy, bringing more useful energy to our systems, means improving energy-conversion ratios over the widest possible range of physical, economic, and social processes. We can no longer rely as a matter of principle on brute increases in total energy use. We have as yet to take into account how growth in total energy use carries system effects in heat pollution and environmental imbalance. Limitless energy appears no more possible than limitless growth in populations of physical objects, because the Entropy Law places a limiting factor on total energy use as well as material use.

Substituting energy for materials, however, is not incompatible with improving energy-conversion ratios. Involved is a design principle of great power to create future wealth. Examples include Fuller's geodesic dome, giving a saving of one to a hundred in the use of physical resources to enclose space. Economizing physical resource-use in achieving given purposes, through substituting useful energy, extends to house and community design as both a functional and aesthetic principle. Overhanging eaves and reflective glass are entropically more effective than profligate use of air conditioning. In communities, attention to human group behavior reduces dependence on automobiles, as in Columbia, Maryland, for trips to school and church, or in protection of pedestrians from car traffic. Substituting communications for transportation is far less an entropic burden, where messages are useful. Thus, Dartmouth's president John Kemeny's proposal for a nationwide, automated and computer-based reference library is a great entropic gain. Future universities, seen as television production centers, having two-way networks of communications, and using teachers as tutors or coaches or educational managers, but not lecturers offers similar energy-conversion gains.

## Using Knowledge to Retard Entropy

The second strategy for avoiding or postponing the Entropy Trap involves bringing more useful information to bear on social and economic processes. The strategy is likely to generate (1) new definitions of the content of wealth and welfare, (2) a new principle of selection of economic processes and technology, and (3) a new formulation of economic growth policy. Such a revision of the strategy of advance in industrial societies also will revise the means of allocating the costs of growth and financing them.

To bring more useful information to bear on social and economic processes calls first for reorganizing education, to aim it at Life in all its manifestations and at imbuing the processes of education with communication of universal pattern and configuration. Such an "invasion" of education by innovation creates new wealth and devaluates old wealth. The new wealth is entropically a gain of many magnitudes, and it is likely to stimulate the growth of wealth in unforeseen amounts. From the viewpoint of the morality of science as natural philosphy, our slow reorganization of education is both dangerous and wasteful. Second, the strategy calls for revolutions in the nation's communications style and policy. The age of specialization risks destruction of the vestiges of a "public philosophy" through the proliferation of "sub-cultures" and obstruction of economic advance from ignorance and fear of advanced technology. Turning the point around, the conception of the media as to their role, and the view of corporations as to their responsibility in communications also need revolutionary change. The media role should be to seek for positive as well as negative understanding. Corporations should communicate what they do and why and how. Such changes in policy bring more useful information to bear generally on social processes.

## New Concepts of Wealth

To be more specific, bringing more useful information to bear means inventing new systems of measurement for social and economic processes in order to bring about a perception of these processes more consistent with a global view. The pay-off in such new measurement systems is a changed perception of social and economic processes that will permit the creation of new wealth. New wealth, be it remembered, competes with and destroys old wealth while adding to human welfare. To create new wealth, in a period of a change in world-view, people must be able to "see" the possibilities of advance and welfare in doing so.

Keeping in mind, then, that wealth itself has an anthropomorphic aspect (even the simplest of physico-economic measures, *efficiency*, requires human beings to specify purpose), it seems that if perceptions of wealth are to change, then measurement systems have to change. All this seemingly remote concern for perception is at the heart of developing policies for balanced growth. The present is a time when one world-view gives way to another. How is the new world-view to be imparted? In the personal sense, as has been said above, it is to be imparted by restructuring the communication of knowledge. In the technical sense, the new world view has to be imparted in new measurement systems, which correspond in conception with the new understandings of the 20th century scientific revolution.

In other words, new content has to be given to concepts of wealth and welfare, in a deeply technical sense. The substantive reason imbedded in the scientific revolution itself is that a new economic strategy is called for. The new growth strategy defines the content of wealth not only in terms of gains in productivity, conventionally defined, but also in terms of entropic efficiency.

The technical issue is to include new systems of measuring social costs and benefits in the calculus of social and economic processes. The principle has many applications, only sketched here, in relation to redefining wealth and welfare. One application is the rapid development, as recommended by the National Academy of Science and Engineering, of worldwide systems of measuring in physical terms the state and changes in the state of the physical environment. A counterpart, equally important, is similar systems of measuring the social environment, at least in the nation, and if possible, worldwide (6). Far larger resource-investment in environmental measurement systems has a high pay-off in bringing more useful information to social and economic processes, while suppression of information is threatening to human survival.

Another application lies in fuller social costing of environmental impacts of economic processes. It should be understood that fuller social costing changes the content of concepts of wealth, costs, productivity, and income. New systems of measurement can "internalize" social benefits and costs of environmental impacts over a wide range. Doing so will allow for market evaluations to shift the structure of production from processes rapidly creating large amounts of waste and pollution to processes —in some portion, entirely new ones —that slow the growth of waste and pollution. Fuller social costing of private production gives a generalized answer to the question of who pays for change and how. The answer given is that, through the market, the risks of enterprise in the face of social costing are borne as before in a complex combination of producers and consumers, but a combination in which costs of devaluating capital are widely shared according to market principles of independent jugment.

Fuller resource costing operates through pricing principles. The price of products or services rises in proportion to their environmental drain, either in production or use. The price, relative to theirs, of substitutes having lower social costs, will fail. Consumers, paying fuller social costs, remain free to choose. But surely, some processes whose private benefits now exceed their private costs, will be driven out of production by high new social costs.

## New Principles for Selecting Economic Processes

The recognition of entropy in economics creates a new principle of selection of economic processes. How could any change be more powerful and pervasive than a new principle of selection in evolution? The dogma of "Bigger and Better" is replaced by a maxim closer to "Smaller is Better." Economic value becomes identified with minimizing the drain on resources and the environment of a given economic process and function. A new policy goal for balanced growth is to discover and attain a degree of pollution control at which the cost of a little more control or prevention just equals the benefits —both private and public —of reducing pollution.

Fuller social costing that creates a new selection principle for social and economic processes requires developing new social indicators of benefit and cost. Far more investment is needed at once in creating both environmental and social indicators. The technique of technology assessment is only in its infancy. These new systems of measurement are vital to fuller social costing.

To formulate a new policy of balanced growth requires fuller understanding of the role of knowledge in the social and economic process. Knowledge, or something amounting to knowledge by virtue of a highly improbable structure, is the only thing that can grow or evolve in the process of cultural evolution. While Zero Economic Growth as a policy appears to overstate the constraints on the economic process, Zero Population Growth appears to understate the constraints, according to present understanding. Mankind needs to give more concern to the long term future in making present decisions, since these decisions change the process of cultural evolution. In concept the concern should be aimed at maximizing what Georgescu-Roegen calls "total Life Quantity," that is, the sum of all individuals to be alive in the future. Zero Population Growth, it could be argued, takes too superficial a view.

## Organizing —Knowledge

In considering knowledge as a process, Kenneth Boulding distinguishes between "printing" and "organizing" as forms of knowledge. Printing refers to the ability of a structure to reproduce itself, to make a copy of itself. We see this in the behavior of genes. We see it, Boulding points out, in the mass production of physical commodities, which is largely three-dimensional printing. Rote learning and basic emotional sets are a neurological form of printing. Organizing knowledge, by contrast, is the action of a gene in generating its phenotype —"As ye sow, so shall ye reap." In this sense, an idea creates an organization. Or an industrial strategy for a nation organizes its economic history.

What shall be the organizing knowledge that creates the social and economic development of the United States and the world in the decades ahead? The process of economic development is not a process of "printing" but of "organizing" knowledge. No system of equations can describe an evolutionary process in which novelty is inherent. The United States, it could be argued, is in a period of economic development when organizing-knowedge rather than printing-knowledge represents its major comparative advantage, in relation to Western Europe and Japan. Our dynamic comparative advantage appears to lie in low-cost agriculture (not allowing for fuller social costing) and high technology products and services. Our earlier advantages in mass production are being reduced.

To explore further the idea of organizing-knowledge, consider the concept of capital. The traditional view of capital is physical capital —physical structures such as plants and equipment, schools, buildings, and the like. But, in considering the role of knowledge in economic processes, we can see that capital, as economic value, refers to the value of the knowledge imposed on the design of physical capital. In essence, from an economic view, capital consists of knowledge imposed on the physical world. Economists are trying to develop and measure a concept of "total capital" that includes intangible as well as tangible resources. The idea suggests that, to increase our capital, we should concentrate our energies on knowledge processes —that is, on organizing knowledge.

A new growth strategy of bringing to bear more knowledge and useful energy in order to slow down the growth of waste and pollution in effect introduces into growth policy a far longer time dimension than is now possible to cope with effectively. Governmental and business policy is more and more geared to short run payoffs. Government, by taking on more operational responsibilities, subjects itself to more evaluation in terms of short run benefits and costs. Corporations, now largely managed by professionals, are under short-term scrutiny of investment analysts and portfolio managers having stringent performance standards for short run investment objectives. For top corporate executives, the pressures of short run profit results are implacable. To the extent, then, that planning horizons for balanced growth objectives must be lengthened, the lengthening has to be built into the benefit-cost measurement system both in government and in business.

## *Sustainable Growth*

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*Given that new concepts of growth and its relationship to new societal values and the quality of life are emerging what growth can we expect, and what changes must we achieve in our fundamental philosophy? Chester Cooper discusses these questions in his invited paper, with a viewpoint of ZPG differing with that of the preceding author.*

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Before embarking on an inquiry into the relationship between growth and the Good Life, it is important to advance one preliminary observation: *Population* growth as opposed to *economic* growth is not at issue. No society can make perceptible improvements in its quality of life if its energies are absorbed in providing survival kits for its human census. And while economic growth, at least as measured by GNP, is related in part to population growth, few societies currently in the "have-not" category can honestly promise its members anything but a continuing struggle for existence unless it moves vigorously and expeditiously toward effective family planning. This is becoming a matter for serious consideration even among the "have" societies. Thus, Zero Population Growth (with a few, trivial exceptions) must now be regarded as an essential goal for any society concerned with providing a meaningful choice of life-styles for its members.

The question of *economic* growth is much more complex and subtle. Here, the issue is not *growth* or *no-growth*. Nor does passage to Utopia come with a firm and unequivocal vote for Zero Economic Growth.

Two fundamentals condition the prospects for achieving some measure of societal well-being: a substantial sector of society must have access to discretionary income, and a society must be able and willing to provide services and amenities over and above minimal necessary law and order and security from external threats. Obviously, neither the existence of discretionary income nor a socially motivated government elite, alone, is sufficient. The quantities, the kinds and the quality of social services, whether in the form of police protection or nursing care, reflect the choices and expectations manifested within the society.

### Need For Discretionary Income

The amount and distribution of discretionary income available to or on call in a society is a product of past (and, to some extent, anticipated) economic growth and of governmental policy with regard to the distribution of the fruits of such growth within the society. It is no accident that "poor" societies have inferior educational systems, medical care programs and mental health facilities, regardless of the aspirations and desires of their people. On the other hand, if "rich" societies do not reach out for excellence or at least adequacy in these and other fields, it is because either they have chosen not to do so, perhaps because of other priorities or because of cultural or religious constraints. Thus, economic growth has been a necessary, but not a sufficient, condition for making possible the exercise of meaningful choice on an individual level (how many hours of work and how many hours of leisure) or on a societal level (how many visiting nurses in a town and how many children in a classroom).

Clearly, then, if a society is to entertain realistic aspirations to move beyond the level of more survival to a more advanced state of social fulfillment, the size of the proverbial "pie" must exceed minimal critical dimensions and must be sliced so that there is enough to go around. For many societies, especially but not exlusively less-developed societies, a moratorium on baking bigger pies (no growth) would not only be patently unjust, but would be a recipe for domestic and international tension. In any case, we are probably addressing an academic issue; it seems unlikely that any responsible society would permit it to happen especially as a voluntary, self-denying act to satisfy the advocates of Zero Economic Growth.

## Need For Social Services

The balance struck among social services as well as between services and industrial production in a society is a reflection (in democracies at least) of the desires and aspirations of its members. This is the case, even though competitive, sometimes countervailing individual and social desires and even though unresponsive governmental and corporate bureaucracies prevent anything like a perfect match between what is wanted and what is provided.

But even if the system were much more efficient and the signals dispatched to government and corporate policy makers were more sharply discernible, time lags between decision and implementation would have to be reckoned with. Modern societies (and this encompasses virtually every society concerning us here) are complex, any consequential shift in policy, either government or corporate, involves a cycle of research, planning, decision making, staffing, and implementation more likely to be measured in years rather than months. And in the meantime, new concerns, revised expectations and perhaps new knowledge may make yesterday's decisions redundant or even counter-productive in terms of today's requirements.

## Growth and Stewardship

Any critical inquiry into the concept of growth invokes considerations of the future. But humility as well as prescience is important here. Such deliberations, particularly if they evolve into prescriptive forms, intrude upon the lives of those to come. We must, as we project our thinking, be wary of the traps that lie in trying to penetrate the mists of distant decades.

who, as he attempted to portray the future in the mid-1940's, would have been able to sketch more than an abstract impression of our world today? The kind of judgments we wish to make about the future are much more complex than can be provided through the extrapolation of a few selected statistical series.

Since the concept of "stewardship" implies present restraint for the sake of future benefit, we would be prudent to limit our considerations to a few decades ahead. Personal, even collective, discounting of the future becomes increasingly great as a society plans for generations it is destined never to see. This takes on a different dimension, however, when one contemplates the span of a generation or two. Only the pathologically hedonistic would not profess a readiness to limit current consumption in order to leave something of value for his children, possibly for theirs. This impulse varies from culture to culture, from society to society, from income level to income level, indeed from individual to individual. It has been particularly strong in the United States, which might explain why economic growth has been such an important element in American policy and mystique. In any case, somewhere between profligacy and miserliness, most men in most societies have long conducted their personal affairs with the concept of legacy in mind. On a societal basis, however, at least until the recent past, this concept has tended to be ignored; personal legacies were one thing, collective legacies another.

Savings and the accumulation of capital are the usual means for funding growth, especially in industrialized societies. Savings, of course, are the product of abstinence; by consuming less than their income, individuals or communities can produce surpluses which, through the mechanisms and institutions of modern societies, can be so invested as to enlarge the stock of capital. Much of the present concern about growth and stewardship stems from societal and individual confusion about the process of capital accumulation and the consequences of its dissolution. If by capital we mean, as the economists do, investable funds or plant or equipment, its accumulation provides the foundation for further economic growth and its expenditure, deterioration or depreciation can be replaced. What troubles many of those who are uneasy about the future is that economic development involves invading the stock of nonrenewable resources and of starting what may be the irreversible pollution of the environment. And while miserliness in the expenditure of depletable resources is obviously a masochistic and self-defeating policy for those now inhabiting the planet, profligacy and carelessness by individuals, corporations, or societies as a whole cheats future generations of their rightful legacy. Thus, collective stewardship must take two forms: accumulation of capital through saving and investment; restraint in the depletion of non-renewable resources and in the pollution of the environment.

There are distinguished scientists who make the point that technological breakthroughs have expanded the resources horizons by several orders of magnitude over the past century and that technology can be counted on to do the same for generations to come. And there are eminent economists who maintain that the market place and the price mechanism will provide warnings of the dangerous curves and road blocks that lie ahead in sufficient time so that individuals, corporations and whole societies can alter their course.

It must be acknowledged that, to the extent that history over decades past provides evidence, these views are persuasive. But, it must also be recognized that scientists and economists must ply their trades within the system —a system which, in virtually every country of the world, has become increasingly complex and constipated. In short, technological and economic solutions, if they exist, may not be implementable or even perceptible in time to help over the tricky decades immediately ahead. Relying blindly on technological innovation or economic forces may be playing roulette with the future.

## Characteristics of Sustainable Growth

If growth, especially economic growth, is to be addressed as an issue of public policy, particularly in terms of its relationship to such nonquantifiable concepts as the Quality of Life and Stewardship, the matter is much more subtle than the discussion, thus far, may indicate. To imply that the question can be put in terms of growth or no growth is to oversimplify the central dilemma. Few knowledgeable people would argue that in the industrialized countries economic growth should (or even can) proceed for more than a few more decades without regard to the profligate consumption of energy and non-renewable resources or the despoilment of the environment. Nor would many argue that a halt to economic growth would be a valid, universal solution to the present predicament. Indeed, it is implausible to suppose that any single formula could be generally applicable, given the enormous present disparities in income levels, cultural backgrounds, popular aspirations, and population-resource ratios. Although growth obviously means something very different to the already-developed as opposed to the developing areas of the world, growth as opposed to stagnation is ingrained in the political, social, economic, and psychological fabric of virtually every westernizing society. Perhaps the most that can be said is that, with prudent consumption of non-renewable resources and with careful consideration for the environment, the moment of truth for economic growth can be pushed back several generations during which time growing wisdom, technological progress and institutional innovation may provide some solutions that are not now discernible.

In thinking about the longer term, the concept of sustainable growth may prove a more useful point of analytical departure. Sustainable growth is not only that rate and kind of growth which the economic calculus and the resource traffic will bear, but the rate and kind of growth a society, for a variety of reasons, is anxious to achieve or able to tolerate. Thus, sustainable growth should not be interpreted as "sustained" growth. Indeed, some countries (Holland is an example) may have already passed the point where sustained growth is sustainable. Sustainable growth, then, would take the form of a conscious national or societal *objective* as well as a *process*. It implies certain reasonably well-defined views about the long-term future, both in terms of available resources and of needs and aspiration. This, in turn, assumes that governments, as well as large corporations have the willingness and capacity to engage in meaningful long-range planning and that policy and decision-makers have adequate information, tools and techniques for gauging a society's aspirations and for measuring the effectiveness of response.

The choice of the adjective "sustainable" to modify the noun "growth," was influenced by several considerations:

1. The inquiry should be projected into the future rather than simply consist of an analytical snapshot of the present. Thus, in the light of what we now know (or think we know), what forms and directions of economic growth would best meet the requirements and aspirations of our own generation and yet not place in jeopardy the requirements and aspirations of the generation or two to follow?
2. The concepts of growth, quality of life and stewardship must be represented in the matrix of the analysis and in any prescriptions that might flow from it.
3. Advocacy of Zero Net Economic Growth, on the one hand, or of continued rapid economic growth, on the other, has no validity as an abstract concept: to the extent that either may be valid depends on detailed analysis of particular situations. In any case, neither position can be wholly right or wholly wrong: present amenities are largely the consequence of past growth, but the indefinite continuation of past rates of growth will almost certainly be constrained by physical and institutional factors.
4. From this follows that the optimum growth that may apply to one society cannot be generalized as a model for others, and that a generalized model is likely to have limited applicability at best to any particular society. If this be so, generalized models and the prescriptions that flow from them are likely to be of little practical use to planners and policy-makers.

5. Judgments with respect to the kinds, directions and rates of economic growth appropriate to a particular society obviously must take account of such quantifiable factors as mineral and agricultural resources, size of population, levels and distribution of income, accessible, useable land and availability of fresh water. But they must also be based on the political, social and economic institutions and the cultural and religious patterns which may stimulate, constrain or even shape the environment in which economic growth takes place.
6. Account should be taken of the international tensions that may arise and the adaptations and new institutional developments that may be required to cope with resource and environmental constraints and differential rates and directions of growth.

There are those who argue that physical constraints need not inhibit economic growth over the long term. Confidence in the problem-solving capabilities of technology and the regulating capabilities of the price mechanism looms large in this bullish view of the future. There is much to be said for such optimism; we need only look back over our own lifetimes for impressive, corroborative evidence. Invention, innovation, and adaptation since the eighteenth century have eased past problems of population and economic growth.

One can be justifiably uneasy about the future, however, without derogating the accomplishments of the past. A gnawing question is whether the pace of technological, economic and social change can continue to keep up with the problems created by ever-more rapid growth and its accompanying environmental degradation, physical clutter and social tension. There is no dearth of technical plans to save the cities, clean up the rivers, dispose of solid waste. But, unhappily, there is also no dearth of public lethargy, political inertia and institutional rigidity. Thus we continue to confront rotting, virtually bankrupt cities, congested highways, energy shortages, and frequent "pollution alerts."

It seems clear that the cultural, political and social characteristics of a society will play an important role in influencing the direction and shape of its economic growth. Indeed, these factors may have a more important effect in constraining or channelling growth than the decreasing availability and increasing cost of non-renewable resources. But the unplanned movement of growth into lines of least institutional resistance is not necessarily a formula for achieving a pattern that is sustainable over the long term.

## *Who Pays for Change?*

Economic growth has many costs. Included are the cost of investment and foregone consumption, foregone leisure, the destruction of capital made obsolete by new products and technology and others. The costs of growth are spread throughout the economy and Madden concludes that the costs of change can be borne. Basically, growth can be financed from the additional income derived from growth. Madden's discussion is presented below.

## The Change —Costs of Growth Are Widely Spread

Economic growth, as portrayed here, refers to the increase in the capacity of the economic process to provide whatever values have the highest priorities in a particular society: more goods, of whatever kind most desired, or more services, or even more leisure (7). There is no one optimum rate of growth, since growth itself is not free of charge, but has costs that rise disproportionately with its rate, and with its benefits. It is meaningless to express economic growth as a percentage increase in some index, since the composition of the growth increment is as important as its size. In farm economies, growth in agricultural output may have the most meaning. After the food and fiber criterion come durable goods. And after the durable goods standard of growth, perhaps come Abraham Maslow's higher human needs —of belonging, esteem, and self-realization —in education, in travel, in leisure, in helping others, in getting-away-from-it-all.

Certainly, in a consumer-oriented society, we must balance the benefits of growth against the costs of achieving various growth rates, to establish at a given time a desired rate of growth, not necessarily the maximum rate. Economic growth has real resource costs: the values foregone in acquiring it. In the pursuit of balanced growth, we must not lose sight of other goals, such as individual freedom, the flexibility of private enterprise and market responsiveness, or the principle of limiting the role of government.

As explained earlier, in an enterprise economy dominated by markets, the change-costs of economic growth are widely spread throughout the economy. Even at times of nearly full employment, some areas or industries have high jobless rates, and even in prosperity, some regions and industries and occupations are under-paid. However, the period since World War II has seen an epic migration or rural blacks to urban areas inside and outside the South, with resulting gains in real income and some (though not enough) gap-closing as between median income of white and non-white families.

Measured by expectations, the change-costs of growth may appear inordinately high. However, measured by performance in raising real incomes, by mobility patterns of large groups, by international comparisons, and by standards of consumption, it is difficult to resist the conclusion that the change-costs of growth have been widely distributed in the United States.

## Growth Has Economic Costs

At any one time, the rate of growth depends largely in a complex industrial economy on the share of resources diverted from current consumption for investment purposes. Investment has to be broadly interpreted to include any economic activity which increases the total supply of productive resources or improves their quality. Productive resources of course include managerial and technical as well as other labor skills and supplies, so that investment includes education and research as much as power plants and machine tools.

Two ways are available to increase the rate of growth: raising the share of current income allocated to investment, and increasing current income itself. To increase current income, we must use existing resources of capital, natural resources, and labor more intensively. More intensive use of human skills means the sacrifice of leisure. To the extent that increased labor use is a reduction of joblessness, it is costless in all but the drain on natural resources and the environment. It is costless, that is, in foregone labor services. Leisure, when freely chosen, is a form of income. Idleness, on the other hand, is the deprivation of income; it is involuntary, not a matter of choice, yields no income, and has no economic uses.

If increased leisure is a human goal, in other words, is one of the goods and services for which we work, then it has a value and a cost. The value, measured by the cost, is the foregone growth. Thus, it is hard to make comparisons; as between a five per cent growth rate and a three per cent growth rate, who can say which is more desirable? It is not even possible validly to hold that in all countries and at all times, growth as measured by national income statistics is better than no growth. National income statistics omit the value of leisure, either as income to people or as the contribution it may make to the total supply of goods and services. The loss of leisure values in order to achieve more rapid growth has to be counted among the costs of growth. In short, growth costs leisure.

Growth not only costs leisure, it also costs consumption. To speed up growth, and so to speed up gains in per capital income, takes investment; and comsumption has to be given up in order to invest more. Saving and investment are made possible through abstinence and work. By working more, and thus getting more production and income, both more saving and investment become possible. In short, the costs of growth are the leisure and consumption given up to get it. Presumably, these are given up in the present to get more of them in the future.

Another cost of growth, borne by owners and, to some extent, by managers, is the cost of creative destruction of capital. New technology, plants, products, and services may render existing capital obsolete, and thus impose costs in the form of lower capital values on the owners of productive resources. This is true of capital equipment, from which there is in effect an involuntary disinvestment by owners (although this disinvestment is voluntary so far as society is concerned). Similarly, human beings sustain a loss in "human capital" when their knowledge and skills become obsolete because of new knowledge and skills or because they are supplanted by capital equipment. Localities and broader geographical regions may suffer substantially the same costs in that their "capital," their specialized contributions, is rendered obsolete, supplanted by more productive resources elsewhere. These costs are unavoidable in a dynamic society. They could be held to a minimum in a static society, if it were possible in the face of presently available knowledge already extant but not used, to maintain one. But given the pressure of existing, unusued knowledge on existing institutions, it is doubtful that the social organism could avoid the requirement of change, either advance or retrogression.

Many displaced resources and workers can be reabsorbed in the economy, but only by incurring the costs of shifting from one use or place to another. Of course, in a dynamic market economy, these shifts are going on all the time. Mobility costs are incurred in changing jobs, in changing occupations, in moving from one area to another. However, corresponding to these mobility costs are mobility benefits. In general, the costs are borne by owners of resources, but typically they are shared at large by society through the tax structure, which provides some offsets both for capital and labor costs. A sharing of displacement costs also is accomplished through various private and government programs, such as company-provided moving costs, terminal pay, retraining programs and government-provided manpower programs.

The extent to which private corporations today are charged for costs borne by business for social purposes is not well known, but it is already substantial. The costs referred to are costs not directly related to production of output. They include: (1) Federal corporate income taxes, (2) state and local corporate income taxes, (3) property taxes, (4) sales and gross receipts taxes, (5) miscellaneous state and local taxes, (6) occupational safety and health costs, (7) pollution abatement costs, (8) social security costs, (9) unemployment and workmen's compensation costs, (10) health insurance costs, (11) private pension costs, (12) group life insurance costs, (13) temporary disability costs. This list is not inclusive, but these costs alone probably amount to a substantial share of gross corporate product, perhaps one-sixth or even one-fifth.

It should be obvious that, up to now, benefits have exceeded costs of growth, as measured by rapidly growing population and living at unprecedentedly higher standards than ever before, both here and elsewhere in the world. The issue of the future is how to maintain the increase in the capacity of the economic process to provide whatever values have the highest priorities in the particular society, economic growth, while slowing down the rate of growth in waste and pollution. Economic growth, as defined here, is required both (1) to attain new values of high priority and (2) to slow down the rise of waste and pollution.

## The Economic Costs of Growth Can Be Borne

How to pay for the costs of change is the source of most discussion and criticism of growth. This is a highly important question because how we decide it will have significant and long-lasting effects on the allocation of resources, on the efficiency of their use both in productivity and in entropic terms, and therefore on the ultimate satisfactions derived from the economic system. Valid economic calculations, relating benefits to costs, and thus setting values, is the *sine qua non* of an effectively functioning economic system.

The essential task of economic calculation is performed through the market system. The market system prices both output and input, i.e., productive resources of capital, labor, and natural resources. The system provides a continuous feedback of the cost-benefit relationships. In the market, the costs of change and growth are being paid all the time, in dizzying array. For example, the 21 million United States citizens 65 years and older have adjusted to the telephone, radio, television, automobiles, propeller-driven airplane, jet plane, and the like. They have adjusted to massive shifts in population that since 1910 has seen the Industrial Crescent, from the New England mill towns through the states bordering the Great Lakes to west of Chicago lose relative shares of prople and jobs to newer regions. They have adjusted to equally massive changes in taste, fashion, and behavior norms.

Throughout this period of massive change both the political and economic systems have remained largely intact, but with a continuing trend towards an increased role for government in the society and a trend toward public and private provision of various forms of indemnity payments against industrial risks of injury, illness, and old age. Poverty, although its official definition has been redefined higher several times, has declined from perhaps two-thirds to under one-eighth of the population.

As early as 1963, the business community had concluded, as mentioned earlier, that "ours are now largely the problems of wealth and success," that "the extremes of poverty, if not entirely eliminated, are no longer economic, but political and social problems." The business group implicitly acknowledges in this statement the principle that, in a balanced way, the costs associated with growth should be financed from the increment of income derived from growth —the growth dividend. The conclusion thus appears strongly persuasive that the economic costs of growth and change can be borne in our society. The issue remains that of how to assess these costs.

## *Implementing Change*

In general, the costs of change should be levied consistent with the flexibility and responsiveness of the market system. That the system is responsive to new demands placed on it is illustrated by the "social responsibility" issue in business. The idea that corporate business responsibilities should encompass social issues was fairly novel in 1966, but by 1973 was widely accepted by major business and banking leaders (8). As Donald A. McNaughton, Chairman of Prudential, has pointed out, in the 19th century the corporation concentrated on economic performance, and in doing so, invented new measurement systems for evaluating economic performance. Today, given the public demand for quality of life, the corporation is called on to develop new social measurement systems.

Madden points out that business needs incentives to implement social responsibility. Profitizing social output or finding ways to develop social demands into new markets are suggested as possible incentives. Government policies which could provide incentive are also presented. He also discusses the need for methods of measuring social output so that it can be properly managed and directed. Corporate Social Audits are suggested as a measurement device and a typical Social Audit is outlined.

### The Profit Motive and Other Incentives

The problem facing the corporation is how to meet the various demands for "socializing" its output when its operations are based on satisfying private demands. The corporation has always had a responsibility to society, derived from its franchise from the state. In the nineteenth century, its major goal was private production of material goods and services, to raise material living standards. Today's emphasis on social responsibility makes of the corporation a social as well as an economic organization, willy nilly, since corporations succeed by producing the values people want. Whether social-and-economic, or merely economic-as-in-the-past, the corporation is motivated and disciplined by the market mechanism and the profit motive in a competitive economy.

To meet new demands, as we have seen, the corporation is re-examining cost concepts. It is also examining possibilities of turning social demands into new markets. This requires market research to find which of the new demands a given corporation could meet, what it would cost, how it could respond. Since social responsibilities are "layered," the corporation has to anticipate (1) which are legal requirements, (2) which additional responsibilities the public expects, (3) which are newly emerging social demands, and (4) which emerging demands prompt an activist role for business.

Business has to "profitize" corporate social performance. A key aspect of the current corporate "social responsibility" movement is the lack of balance between the business resources available and the new social commitments of the individual business firm. The before-tax residual after private costs average less than 10 per cent of sales. For almost all corporations the current demands on this residual, beginning with taxes, are great. Federal income taxes took 44.7 per cent of the profit residual in 1971, for example. Since fulfilling such social responsibilities as helping to reduce pollution are costly, the cost must be borne somewhere else. And, to the extent that environmental control facilities require real resources for their production, producing them draws off those resources from other uses. This point was underscored at the UN-sponsored Stockholm Conference in June 1972 where the under-developed countries, as well as the poor in the industralized countries, interpreted improving the quality of life as increasing their material consumption.

Since business cannot be expected to perform its proper role of effectively using resources in production without a profit incentive, business must have a clear reading not only of consumer preferences but also of the new ground rules of government in meeting these demands. Government has to set guidelines that allow business to privatize social costs; otherwise corporations follow their individual interests rather than the social interest in the absence of guidelines. To the extent, then, that government sets the rules to conform to social costs of private production, corporations respond consistently with consumer preference.

Traditional maximizing of profits is already too narrow, if it refuses to concern itself with social and ecological problems, for today's large, high-visibility corporations. Few alternatives are left: (1) the "stick" of legal requirements, (2) the "carrot" of government contracts or subsidies or (3) direct allocation. To make the "carrot" approach work, government, in principle, has to subsidize enough to make rates of return competitive with other uses. But the risk factor can be high in meeting new social responsibilities, depending on consumer preference. Whether Congress would indemnify all the extra risk is not so clear judging from recent experience of defense contractors and their ownership shares in the market.

Direct allocation could take various forms. One business leader has argued for establishing "minimal profit" subsidiaries to perform social services. However, this solution is peripheral to the basic need for a change in the strategy of economic development, to increase output (value) but slow down the growth of waste and pollution. It should be clear by now that such a new strategy is far more pervasive in its influence over the entire range of corporate activity. Direct allocation could take a compulsory form. A law could require firms over a certain size to invest a specified percentage of their assets to produce social output. Already, foundations are required to disburse annually a given percentage of their assets in order to retain their favorable tax status. One result might be more corporate philanthropy (currently tax deductible, within limits). But here again, does this approach go to the heart of the corporate role in society?

No doubt, in any event the corporate-business relation is in for change, as the distinction blurs between production of private and public goods. Many demands on corporations for more social responsibility are being made by those who spearhead the corporate responsibilities movement: (1) tough new regulation, (2) breakup of large corporations, (3) federal charters for all corporations, (4) public directors for firms over a given size, (5) publicly elected directors, (6) shareholder rights enlarged to raise social issues, (7) due process rights for corporate employees who "blow the whistle" on corporate practices, (8) personal criminal accountability of corporate officials for some public offenses, such as pollution, (9) suspension of advertising for convicted fraudulent advertisers, (10) a concept of "social bankruptcy" for companies whose social costs exceed its private and social benefits, (11) public examination of corporate tax returns, (12) required recycling, (13) active manpower policies required for minorities, (14) required participation in solving urban problems, (15) required increase in voluntary contributions.

How can business operate as an instrument of public policy? One way is through government standards of minimum performance, with penalties for failure to meet them. Another is through business-government consortia. A third is through private production of public goods. The third approach would require a radical change in national economic policy. The suggestion is that the market-oriented government-business cooperation would be for government to invent public goods on the demand side (i.e., including the creation of a market-type demand), and for business to compete in investing and promoting public goods on the supply side. Could corporations market new garbage disposal systems, new and economical education TV programs, systems for delivering health care, systems for setting up public parks, systems for renovation of slum housing, or the like?

### Corporate Social Aduits to Measure Social Output

The corporate "social audit" or "social accounting" device represents the beginning of a new measurement system, by which corporations can examine what they are doing and gauge their performance. The social audit is intended as a tool to enable a corporation (1) to review its performance against accepted social objectives, (2) determine the dollar value of its commitment, (3) evaluate to the extent possible the "social impact" of management decisions, and (4) determine how much corporate social involvement is in the self-interest of the corporation. Professor Raymond A. Bauer of the Harvard Graduate School of Business, a leader in the search for a workable social audit, has concluded that the first three of the four steps of the audit set down above are now possible, but that the fourth will be extremely difficult accomplish.

Although formal social audits have not yet been devised, some large corporations today are keeping track informally of their own social performance. About 60 per cent of the top 500 corporations included an account of some aspects of their social performance in their 1972 annual reports, up from 35 per cent in 1971.

A typical social audit might cover such aspects of corporate operations as: (1) Employee Relations, (2) Minority Enterprise Development, (3) Environmental Protection, (4) Contributions, (5) Community Involvement, (6) Consumer Affairs and (7) Organizational Reevaluation.

To decide how far to go in filling any gaps in its performance, the corporation has to make some kind of cost/benefit analysis, but social benefits are difficult to quantify. Indeed, a calculus of quality will be needed to evaluate benefits, and it may turn out that polling techniques, as Raymond Bauer suggests, are as valid measures as can be developed. The business firm's effort to "internalize" costs of social improvement programs are, in effect, efforts to broaden the concept of what once were largely private costs (excluding taxes). Private costs can be reduced per unit of output. But environmental costs of business engaged in physical production rise per unit of output, since waste and pollution are an exponential function of output. Thus, the market mechanism will inhibit production of physical commodities whose environmental costs are internalized. It will do so by raising the relative price of such physical commodities relative to substitutes, thus enforcing more stringent economy in their use and stimulating ways of "innovating around" them in consumer uses. From the viewpoint of social welfare, the relative rise in price of physical products heavy in their environmental drain is desirable. However, consumers have to strike an equilibrium price that balances off their demand for the product against its fuller costing.

But social benefits are even more difficult to measure. Costs are at least represented by outlays. As a bizarre example, infant mortality in the U.S. is higher than in Europe. However, there are suggestions this results from keeping weight gain down for pregnant women in the U.S. compared to European practices. It would be easy to infer, without knowledge of this possibility, that the social benefit lay elsewhere, perhaps in reform of the

U.S. health care system, when all that would be needed is a change in prenatal care of easy accomplishment. Which of a given set of social benefits should be pursued and to what extent —i.e., how much should it be pursued —before the added social benefit of competing uses comes to exceed the declining added benefit of pursuing the social benefit? In other words, since society's resources are scarce, relative to all the desirable uses for them, as greater amounts of resources are devoted to environmental protection, the added social benefit of such spending will fall and the added social cost will rise, causing the added benefit and the added cost to equalize at some spending level. That is to say, even if they are completely known, our social desires can no more be met in total than our private desires.

## *Implications For Economic Policy*

The implications of a global view for economic policy are many and are just emerging into national consciousness. The need for more comprehensive long-range goals and planning which include a wider range of social issues and directly address means of emproving the quality of life is generally recognized.

### Attributes of Successful Planning

Commenting on societal goals, Cooper discusses the need for long-range planning. He believes that there is general agreement about what the goals of society should be. However, government and business goal-setting have been ineffective because the process has been isolated from the planning process. He concludes that planning should be indicative, rather than directive and should be integrative in that it should include physical and social factors as well as economic factors. He briefly discusses the possibility of organizing a national planning staff and summarizes desirable features of such a staff.

Cooper says that, to be something more, and more useful, than a set of lofty platitudes, societal goals must be thoughtfully defined and periodically reviewed. Collective introspection precedent to the development of goals is rare in our own society, and indeed in most others. To the extent national or institutional goals are formulated, they tend to take the form of short-term, specific, quantiatively-expressed performance targets. As a consequence, "progress" or "growth" has tended to be characterized, over the longer term, by lurches and zig-zagging toward unarticulated or viscerally-determined objectives. But one senses that if societal yearnings could be articulated in terms of desired goals, the short-term targets of government agencies, corporations and labor unions might turn out to be irrelevant if not altogether wrong.

Whatever the approach used, there seems to be fairly wide agreement on the priority of objectives. The problem arises when one moves from goal-setting to implementation. A Brookings discussion of the 1973 Federal Budget puts the point well: "There is widespread consensus ... that increasing equality of opportunity, improving the quality of public services, and resucing the environment are, and should be, important concerns of the federal government. There is far less consensus, however, on how these objectives should be accomplished or how success should be identified and measured" (9).

An Administration official also alluded to the gap between aspirations and implementation in testimony to Congress: "It is the conviction of this Administration that public policies for balanced and orderly growth will be more effective than the mechanisms through which they are shaped and carried out." (10).

The ambitious efforts at national goal-setting over the past decade turned out to have little practical significance because they were removed from the planning process. Goal setting is but a necessary prelude to the major task of laying out the routes which will permit policy makers to have a high degree of confidence that the goals can be achieved. Thus if growth is to serve identified ends and if it is to proceed in cognizance of resource availabilities, environmental considerations and societal needs and aspirations, that is, if growth is to be economically and socially *sustainable*, planning by governments and large quasi-public and private institutions is an essential element for success.

"Policy planning", whether undertaken in great departments of the Executive Branch of government or in large corporations has not been distinguished by stunning success. There are many reasons for this which may have little to do with the validity of the planning process, itself. The most expeditious road to career advancement, for example, is through operating rather than planning elements of an organization; few Cabinet members or corporation presidents are plucked from the ranks of planning staffs. Few Cabinet members or corporation presidents tend to pay much more than lip-service to the results of elaborate policy planning studies.

But there is more to the story than simply the bureaucratic handicaps or top-side neglect under which planners typically ply their trade. There are some fundamental disabilities of methodology that inhibit the use of the planning process as a managerial tool. Progress is being made in developing more effective planning techniques, but for many years ahead, at least, we will have to rely on the blunt instruments at hand. This means that emphasis must be placed on *indicative* rather than *directive* planning, on identifying and then analyzing alternative courses of action, rather than, with arrogance unbecoming the start of the art, laying down policy prescriptions.

The analysis of policy alternatives need not be the only responsibility or contribution of planners to the process of translating goals into programs. Along the analytical path critical decision points can be identified, flagged and gamed: "if it is decided to do A, consequences W and X will follow; if Course B is selected, consequences Y and Z will have to be anticipated."

Recognizing, then, that by "planning" we are talking about *indicative* planning, a policy of sustained growth calls for long-term planning undertaken at a high enough echelon to permit direct access to senior decision makers. Such a planning process would involve considerations longer than the annual budget cycle, longer than the four year terms of Presidents or corporate executives. It goes well beyond projecting production schedules or extrapolating sales. The process, in short, involves a scale of time measured in decades rather than years. This kind of planning is not being done in the United States, either by government agencies or in the private sector.

Planning for sustainable growth must also be integrative in the sense that it reflects physical and social as well as economic considerations. Basic to this broad and humanistic approach is a conversion by both planners and policy-makers from worship of the false god of Gross National Product to other, or at least modified, measures of progress. In short, a society must be able to judge how effectively it is performing as well as how much it is producing.

No planning function, whether in or out of government, can be effective unless it is meshed closely with the decision-making process and decision-makers, themselves. Nor can effective planning be done unless planners are able to call on the resources of their colleagues in the operating and research elements of their organizations. The "boys-in-the-back-room" and "the ivory tower" syndromes thus fall far short of describing the nature of the planning process envisaged here —within either the national government or large corporations.

Some governments have already taken steps to develop a long term planning function. In France, the Netherlands and Japan, for example, small, multi-disciplinary staffs of planners are attached to the Offices of the Prime Ministers (11). In each case the staffs endeavor to integrate economic, technological and social planning and, in each case, too, the planning period extends well into the 1980's (12).

It would be beyond the scope of this paper and beyond the frontiers of current thinking to try, at this point, to define the precise charter, form, and organization structure of a national planning staff concerned with sustainable growth. But there are a few points worth noting. We have already emphasized the need for a long-term frame of reference, the need to cut across intellectual disciplines and departmental areas of responsibility and the need for planners to operate from a real-world perspective. The basic approach, as we have observed, should be indicative rather than prescriptive, both in terms of sharpening the choices rather than spelling out specific goals and of analyzing alternative policy options rather than serving up a set of concrete recommendations. A national planning staff should also engage in, or have direct access to, the assessment of the long-range social, environmental and economic effects of the applications of new high-technology. Finally, one would like to think that a national planning staff would act and react substantively with the long-range planning going on in government departments, other governments, the large national and multi-national corporations, and private research organizations.

### Features of a Government —Business Growth Policy

Madden states that action consistent with the new concepts of economics and the global view and traditional policy and economics is needed to provide a humane world in which mankind can achieve short-range goals consistent with long-range survival and also achieve a rising quality of life. People's perceptions must be adapted to new possibilities of wealth creation which include not only physical goods but new social and economic values. New knowledge of the physical and social sciences must be applied move intensively and organized more effectively. Government and business must pay more attention to the changing values of people. The new economic growth strategy for business means developing a functional, social performance-oriented mode of marketing. He suggests the following as principal elements required for a comprehensive government-business growth policy to provide these features.

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It might be desirable for government to create new policy in support of the values of environmental enhancement, research in science, the communication of science, energy, social measurement and analysis, education, and economic policy.

In all these areas —since all are related to concern with the environment —major tasks of policy re-examination consistent with the new world view are urgently needed. It is not so much a question of large expenditures as it is the development of new rules of the game that reflect new understanding of the growth process of the future.

The proposal bristles with implications that cannot all be drawn out here. More progress is needed now in monitoring world weather, world environment, study of farm practices, and a host of related topics, looking towards world-wide management of the world environmental balance. Such basic investment, well-financed, will generate unpredictable new sources of wealth, both public and private. It should be a goal to create world-wide, cooperative environmental measurement and management.

The time is at hand to re-think science and technology policy, not in relation mainly to experiments in utilization, but in efforts to unify science, to communicate it widely, to apply *methods, not technology,* in a broad sweep to social affairs. Multi-media scientific education —that is, superb and entertaining education —needs financing more, far more, than yet another fragmented and unrelated scholastic exercise in scientific specialization. Dartmouth president John Kemeny's suggested national, computer-based reference library should be financed now. At the expense of some old or in effective government program.

Instead of more government education aid to existing universities, some small funding might be provided to a corporation, balanced in make-up, which saw itself as a nation-wide, open, TV university, modelled after the British Open University. Courses should not be allowed that are not multimedia productions.

At some point soon, U.S. energy policy will have to face up to the implications that lie in the plentiful supply of hydrogen, the fact that a few day's supply of energy from the sun equals all the stored energy on earth, and the present positive feed-back between the rise in output and the rise in energy use. Abstractly, the issue would seem to be more GNP (or human value) with less expenditure, but more useful expenditure, of energy. At least, such an inference appears to follow from the thesis presented by *Limits To Growth*.

Social measurement and analysis now languishes partly because of lack of fresh or original study of U.S. statistical systems, now mainly two-dimensional even in economics, where measures of wealth are sadly lacking. Fresh initiatives in statistical design suited to computers, aimed at systems viewpoints, holistically conceived, are lacking. Meanwhile, fears of "data banks" divert interest and confuse purposes, and existing systems of statistics receive patchwork attention.

Education is on the verge of an explosion and of large cost reduction through a radical change in the organization of instruction brought on by technology. How is it that Western Civilization's great artists were financed to communicate the symbolism of Biblical creation to generations, while only Time-Life Science books have dared to portray the creation of the universe in pictures? The pursuit of knowledge is corrupted by comparison to the marvels of fused art-and-knowledge creations lying in every cranny of the society, to become entertainment, whether as drama or as epic narrative, or whatever, combined with education.

Education is on the verge of an explosion also through informal intimacy of discourse by ad hoc groups springing up everywhere, bored by the formal trappings of instruction, but effective in their own fields and yearning for personal conversation, involvement, enterprise, and creation. These are people at home in a nation that is only five hours wide and three hours long; people who are impatient with papers and footnotes, appalled by our society's lack of coherence and coordination, but determined to realize our potentials.

Economic policy stands at a similar threshold, ready for intelligent economic similation and modeling, development of policy analysis, testing of policy changes by simulation and reform of institutions.

All these changes implicit in the new world view represent a new initiative for adaptation of our culture that are breathtaking, but of course require, above all, a new orientation of thought in policy making far more than massive investment in technology. The task lying before our society is that of re-organizing thought processes, images, language, and perception far more than the creation of programs or "solutions" to "social problems."

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Madden outlines some specific elements of economic policy for government and business which he believes should be implemented.

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1. *Creation of Social Markets.* Government should set new priorities to create social markets for private business operation by massive abandonment of our dated and ineffective social welfare and industry—subsidy programs. The missing link in revenue sharing is the creation of social markets for business corporations.

2. *Urban Policy.* Government could initiate broad measures to achieve governance of urban regions, such as a national network combining urban-observatory development banks with a federal-private development bank at the center, in order to analyze and finance urban innovation.

The missing link in revenue sharing is access to knowledge. As mentioned above, the bringing to bear on economic processes of more useful knowledge is a cultural blockbuster of an idea, bristling with design implications. Even at risk of being tiresome, we don't *know anything*, as a people, about what is happening in our urban regions. Most of us don't even know we live in urban regions, except intuitively, since we go to great lengths, using phrases like "urban," "rural," "rural-nonfarm," and "central-city", "suburb," and the like, to obscure our perceptions. How can we think clearly about governing urban regions, not knowing we live in them? We don't even have visual TV or newspaper symbols, like stylized maps, to create any unity of feeling among people in these regions. They have to apologize for saying they live in "the New York area" when they really live in, say, Summit, New Jersey. And certainly we have no visual system of orienting people easily to parts of a metropolitan area. All the buses go to some unknown stopping point like "Kings Park" or "Floating Hill," the name of a real estate development.

At the next level of confusion, we lack any regular means of communication about what is happening in our urban regions. Our newscasters and journalists appear never to have thought of urban regions, except for the weather forecaster. Planning board decisions come after murder, rape, dope, police line-ups, and sports in importance. It is not easy for the *res publica* —the public thing —to escape from such a melange with anything much intact.

But still another level exists, where patterns and configurations of change move with logic, order, and even beauty across the urban scene, as well as patterns filled with ominous foreboding. Nobody ever hears about these except specialists of one sort or another, who seldom talk together.

The idea of bringing useful knowledge to bear in public understanding of what is happening in cities has obviously got a far, far lower priority of value than weather forecasting. If you think about it, weather forecasting is *organized, scientific* observation, arranged in a system, employing specialists financed both by government and business, to give us *knowledge* about the weather. What is the analogy for urban change and development? The idea seems to escape, somehow, through the cracks of confusion in our ability to imagine.

3. *Environmentally—Sensitive Economic Policy.* Government would restructure economic policy consistent with environmental and policy science insights, would revise incentives in order to stimulate the creation of entropy-retarding new wealth, and would remove restrictions to competition that are widespread in law and regulation.

Here again, the proposal is intended to convey implications of the intellectual framework portrayed throughout the above. The task is an enormous exercise in fresh thinking. One example illustrates this point, perhaps apocryphally. A house in Phoenix, having a 20-foot picture window facing the sun, keeps a 20-foot venetian blind closed except at night. But, it is so hard to raise, the owner installs a motor. The appraiser increases the *value* of the house $1,000 because of the blind and the motor. Another house, with ferns and an overhanging eave and high ceilings is valued less —it has no motor and perhaps no venetian blind.

4. *Recommendations for New Business Policy*

a. Re-organize marketing to create holistic, performance-oriented supplies of services.

b. Re-define balance sheet concepts.

c. Engineer holistic product systems to achieve product miniaturization, zero defect reliability, greater durability.

d. Create new marketing concepts of private production of public goods.

c. Exploit marketing opportunities in "new health" —invisible wealth —of holistic community planning, beauty, education, cultural growth, and health improvement.

f. Create new communications and advertising strategy consistent with knowledge as a form of wealth.

g. Create new management attuned to new wealth.

## NOTES FOR CHAPTER 6

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6. See "Social Measurement", American Institute of Certified Public Accountants, New York, 1972.
7. See "The Promise of Growth", Chamber of Commerce of the United States, Washington, D.C., 1963.
8. See "The Corporation in Transition," Chamber of Commerce of the United States, Washington, D.C., 1973.
9. Setting National Priorites—1973 Budget". Charles Schultze, Ed., Brookings Institution, 1972.
10. "National Growth Policy", Hearings before the Subcommittee on Housing of the Committee on Banking and Currency, house of Representatives, 92nd Congress, June 6 and 7, 1972—Part I.
11. In France, The Commissariat General du Plan, in the Netherlands, the Central Planning Office, in Japan, The Director-General for Economic Planning.
12. A good example of the long-term, wide-ranging, inter-disciplinary nature of French planning is "1935. La France Face au Choc du Futur," Commissariat General du Plan, Librairie Arnaud Colin, Paris, 1972. Foreword.

# APPENDIX

Following the successful completion of the QOL symposium in August of 1972, ESD was approached by one of the invited attendees—Anton Schmalz, then engaged as a general consultant on the Federal Assistance Review Program of the Office of Management and Budget—who suggested ESD should follow up on the Airlie QOL symposium with mini-regional versions throughout the country. After discussing areas of mutual interest, ESD hired Mr. Schmalz as a staff consultant to pursue the alternative futures aspects of the intended environmental issues and social sciences book for the Division. As explained elsewhere, the original intent was to institute a dialogue between government officials and invited participants.

The original symposium outline, as developed by Anton Schmalz with Peter House, Philip Patterson, Martin Redding and John Gerba of the ESD staff, is reproduced on the following pages. The outline includes topics assigned to the contributing authors and questions which each author was asked to address within his or her research theme.

## *Research Symposium*
## *Alternative Futures and Environmental Quality*

In keeping with the policy of the Office of Research and Monitoring to encourage research in all areas relevant to the charter of this Agency, the Environmental Studies Division plans to conduct a research symposium addressing "Alternative Futures and Environmental Quality." The symposium will be held in Room 1112, Building 2, Crystal Mall, Arlington, Virginia, March 7 and 8, 1973.

Symposium sessions will explore alternative future effects on the environment of the way in which three pivotal clusters of issues are handled in the immediate future. The issue clusters are:

1. The nature of the environmental crisis.
2. Zero population growth and environmental quality.
3. Implications of alternative growth policies on environmental quality.

The purpose of the symposium is to pursue a comprehensive approach for assessing future research needs and priorities and to delineate considerations for policy and program planning in each of the issue categories. A detailed explanation and outline of the symposium is enclosed.

# *Research Symposium of the Environmental Studies Division Focusing on Alternative Futures and Environmental Quality*

March 7 and 8, 1973
Room 1112, Building 2
Crystal Mall
Arlington, Virginia

Environmental Quality is both an immediate and a long-term issue with many interdependent options, benefits, and risks. The most relevant policies and programs will derive from a periodic reassessment of the implications of evolving issues on environmental quality. In this spirit the proposed symposium is intended to maximize the benefits from both new knowledge and long experience.

The Environmental Studies Division, Office of Research and Monitoring, of the Environmental Protection Agency plans to bring diverse viewpoints together in a research symposium devoted to a reassessment of three major issue areas conditioning environmental quality.

The EPA research symposium is intended to provide a current focus on comprehensive identification of options and alternative approaches to the three issue areas as they relate to environmental quality.

An average of six participants will be commissioned to prepare papers in each subject area. The symposium will be interdisciplinary to provide for the fullest exposure and interaction of viewpoints. Participants will attend all three sessions to ensure maximum involvement in, and exposure to, the three areas considered at the symposium. Papers will be published and distributed nationally. A discussion session of the symposium will be devoted to each of the three issue areas. These three areas are:

1. The Nature of the Environmental Crisis

Diverse views exist regarding the possibility of an imbalance between human institutions and the ecology of the biosphere. General societal support of an ethic to care for the environment may be substantially affected by perceptions of the reality and urgency of a crisis. What are the implications for environmental quality?

2. Zero Population Growth and Environmental Quality

ZPG has been proposed as a national and world goal. Current U.S. statistics indicate ZPG fertility rates. What are the implications for environmental quality?

3. Implications of Alternative Growth Policies

Growth, equilibrium, dispersion of population and industry, and the elimination of pollution all have their costs. The implications of growth in terms of dollars, as well as in terms of environmental quality, social costs and the overall quality of life, need continuous evaluation.

Providing for environmental quality requires a comprehensive, interdisciplinary and long-range approach on the part of people at all levels of government and throughout the private sector.

Principal objectives of the EPA Research Symposium are to delineate: (1) the issues; (2) feasible approaches and incentives for dealing with them; (3) research needed and rationales for prioritizing these needs; and (4) specific attitudes, costs, and other considerations for implementing changes in government and private sector institutions. These considerations will be presented from the point of view of decision-makers involved in policy formulation.

At a minimum, the papers and discussions in each of the three issue areas will address the immediate and long-term considerations in seven categories of questions for each issue:

1. Is there really a problem? What is it? Who says? Why? Have the problem and associated issues been overstated or underestimated?
2. How can we best distinguish between cause and effect?
3. What are the principal factors conditioning solutions to the problem in terms of technical, economic, and social behavior?
4. What can and/or should be done to ensure environmentally sensitive comprehensive planning and decision making? What incentives, regulations or other policies can help:

   a. political officials;
   b. managers and staffs at all levels of government;
   c. managers and staffs in specific institutions, industries and/or geographic regions; and
   d. segments of the general public?

5. What are the considerations for implementing proposed new policies? What are some feasible strategies?

6. Is there any urgency? What are the realistic time considerations for implementing proposed policies?
7. Who should participate in the planning, implementation, and monitoring or evaluation phases of the policy process? Who can or should be responsible?

Environmental issues are inextricably involved with individual or group perceptions of needs, frustrations, satisfactions, etc. These perceptions condition the concepts of relative priorities and feasibility as well as the credibility of policies and, therefore, the degree of support or cooperation forthcoming.

An outline of the three issue-oriented sessions follows. In addition to a consideration of the seven categories of questions discussed above, each participant will address the representative questions listed for the session in which he is a principal.

## *Session I*
## *EPA Research Symposium*
## *Focused on*
## *Alternative Futures and Environmental Quality*
## *The Nature of the Environmental Crisis*

A. Is there an environmental crisis?

1. What are its characteristics?
   a. Immediate
   b. Long-term.
2. New Perspectives on balancing human ecology and the ecology of the biosphere.
3. What do the current trends show for pollution control?
4. Approaches to continue monitoring and assessment.

B. Pros and Cons regarding an environmental crisis.

1. Myths and reality of pollution.
2. Viability and limitations of the biosphere.
3. Lessons learned from the implementation of environmental policies.

C. One approach to averting environmental crisis.

1. The carrying capacity concept (the ecosystem).
2. Resource viability and limitations.
3. Comprehensive government-private sector growth policy.
4. Lessons learned in balancing economic and population growth.

D. Cultural myths and realities of problem solving

1. Human perceptions of cause and effect relationships—the disease model, ego consciousness, and other barriers to objective thinking.
2. Pervasive conditioning factors on problem definition and decision making.

E. Where do we go from here?

1. Highlight concepts of environmental management.
2. How do/can we achieve the technical, economic, and behavioral modifications to ensure an environmental ethic throughout our society?

Representative Questions

1. To what extent is there a convergence of the environmental imperative and the environmental ethic?
2. Has the problem been exaggerated? Has the environmental imperative been correctly stated or overstated? What are realistic standards, measures and policies to ensure nature's balance?
3. To what extent are flora, fauna and ecosystems really threatened today? Is there a long-term hazard? What is our best knowledge of time and tolerance considerations?
4. Do we know enough to validate the imperative of major technical, economic or behavioral change in our society?
5. What are the social, psychological, economic and political implications of an environmental ethic?
6. What would be the time and other major considerations for implementing the kinds of technical, economic and behavioral modifications recommended by each participant?

# *Session II*
# *EPA Research Symposium Focusing on Alternative Futures and Environmental Quality*
# *Zero Population Growth and Environmental Quality*

A. What are the implications of zero population growth?

1. Implications of needs/values/benefits and thresholds of behavior on ZPG and other population alternatives.
2. Social pathology—population density and distribution.
3. Environmental design for optimum group size and to balance gratification and frustration.
4. Federal government activities to preserve and improve environmental quality.

B. Considerations underlying development of environmental policy.

1. Settings.
2. Awareness.
3. Social roles, pathology, density, and distribution.
4. Policy implications.

C. Resource and environmental consequences of population growth in the U.S.

1. Projections and trends in long-range perspective.
2. How population affects resources and the environment.
   a. Land use.
   b. Pollution.
   c. Mobility.
3. Resource requirements and pollution levels.
4. Ecological perspectives.

D. Public and private policy interactions and implications of population policy.

1. Needs/problem identification and assessment.
2. Mechanisms for policy formulation and analysis.
   a. Federal.
   b. Regional.

- c. State.
- d. Local.
3. Mechanisms for implementing policy.
   - a. Incentives.
     - (1) Financial, taxes, etc.
     - (2) Legal.
     - (3) Other.
   - b. Communication.
   - c. Education.
4. Barriers, constraints and options.
   - a. Resources.
   - b. Institutions.

E. What is the effect of ZPG on growth policies?

1. Goals, objectives and comprehensive plans.
   - a. Individual and societal.
   - b. Political: legislative and executive.
   - c. Government operations.
   - d. Other institutions.
2. Strategies for social and economic development planning.
   - a. Incentives.
   - b. Alternatives.
   - c. Communications.
   - d. Education.

Representative Questions

1. What are the traditional conditioning factors which must be considered in any population policy?
2. How can the needs, values and beliefs of people be effectively determined? Is an index of these perceptions feasible? Could such an index objectively reflect the viewpoints of people in their several societal roles of:

   a. Political office holders responsible for policy, program and fiscal legislation?

   b. Career government employees who are responsible for implementing policy and ensuring the effectiveness of delivery systems?

   c. Specific citizen groups or interest constituencies potentially impacted by proposed or ongoing policies?
3. Are changing value systems and life styles significantly affecting reproduction among their adherents? What are the secondary im-

plications of these life styles on concepts of societal roles and responsibility?

4. What are the social psychological, economic and political implications of a U.S. population ethic?

## *Session III*
## *EPA Research Symposium*
## *Focusing on*
## *Alternative Futures and Environmental Quality*
## *Implications of Alternative Growth Policies*

A. Social and productivity costs and benefits of growth.

1. Rethink concepts of productivity, GNP, national income accounts, and other economic measures.
   a. Productivity
   b. Social accounting
2. Diverse perceptions of needs and urgency.
3. Law and regulation, stabilization programs, etc.
4. Incentives.
5. Who pays and how? What are the second order costs/benefits or frustrations, long term good will, etc?
6. Shifts in the employment base:
   a. Decrease in agriculture and manufacturing.
   b. Increase in knowledge and service industries.
7. Expanded concepts of gross national product and productivity.

B. Implications of sustainable growth.

1. Growth vs. equilibrium.
2. Delineate the perceived limits and implications of economic growth.
3. Define sustainable growth.
4. What kinds of growth can a nation or region, or the world as a whole, sustain to achieve maximum economic and social benefits and minimal disadvantages?
5. What kinds of individual and institutional adjustments may be required?
6. Alternative patterns and goals of growth.

C. International implications of growth policy.

1. New concepts of wealth and ownership correlated with resource utilization/consumption product quality, production, employment and quality of life.
2. Rental vs. purchase of goods.
3. Expanded concepts of ownership.
4. Recycling vs. new materials.

D. Who pays for change and how?

1. Rethink concepts of time, priorities, responsibility, incentives, risks, rewards for business as a citizen.
2. Rethink concepts of costs, profits, and return on investment in a longer time frame and including intangibles such as goodwill.
3. Incentives.
   a. Financial, tax, etc.
   b. Legal.
   c. Goodwill.
   d. Other.
4. Considerations for a comprehensive government-business growth policy.

E. How can/do we achieve an equitable, comprehensive national growth policy?

1. Goals, objectives and comprehensive plans:
   a. Individual and societal perceptions of needs, values, frustrations, satisfactions, etc.
   b. Political: legislative and executive.
   c. Government operations.
   d. Academic institutions.
   e. Profit institutions.
2. Strategies:
   a. Incentives.
   b. Alternatives.
   c. Communications.
   d. Education.
3. Priorities.
4. Comprehensive government-private sector growth and priority policies:
   a. Federal.

    - b. Regional.
    - c. State.
    - d. Local.
5. Major considerations for developing and implementing a viable and comprehensive growth policy.

Representative Questions

1. Is comprehensive policy and program planning possible when it involves various levels of government, academic and profit institutions?
2. Can the long term cost/benefits and other consequences of growth policy be identified?
3. Who should pay for changes to achieve environmental quality standards? How?
4. Is it imperative to have a national growth policy?
5. How can regional and local growth policies be effectively integrated?
6. Is is possible to establish or require a consistent growth ethic throughout our society? How?
7. What are the social, psychological, economic and political implications of a U.S. and a world growth imperative and ethic?

## *Research Symposium*
## *Alternative Futures and Environmental Quality*

*March 7 and 8, 1973*
*Conference Room 1112*
*Crystal Mall, Bldg. 2*
*Arlington, Virginia*

### SESSION I—THE NATURE OF THE ENVIRONMENTAL CRISIS

IS THERE AN ENVIRONMENTAL CRISIS?
Dr. Beatrice Willard
*Member, Council on Environmental Quality*

PROS AND CONS REGARDING AN ENVIRONMENTAL CRISIS
Dr. Donald A. Spencer
*National Agricultural Chemicals Association*

ONE APPROACH TO AVERTING ENVIRONMENTAL CRISES
Eugene K. Peterson
*Urban and Rural Land Committee, Pacific Northwest River Basin Commission*

CULTURAL MYTHS AND REALITIES OF PROBLEM SOLVING
Dr. Murray Bowen
*Georgetown University*

WHERE DO WE GO FROM HERE WITH ENVIRONMENTAL POLICY?
Dr. Garret Hardin
*University of California*

## SESSION II—ZERO POPULATION GROWTH AND ENVIRONMENTAL QUALITY

WHAT ARE THE IMPLICATIONS OF ZERO POPULATION GROWTH
Dr. S. Fred Singer
*University of Virginia*

CONSIDERATIONS UNDERLYING DEVELOPMENT OF ENVIRONMENTAL POLICY
Dr. John B. Calhoun
*National Institute of Mental Health*

RESOURCE AND ENVIRONMENTAL CONSEQUENCES OF POPULATION GROWTH IN THE U.S.
Ron Ridker
*Resources for the Future*

PUBLIC AND PRIVATE POLICY INTERACTIONS AND IMPLICATIONS OF POPULATION POLICY
Graham Molitor
*General Mills, Inc.*

IMPLICATIONS OF ZPG ON GROWTH POLICIES
Dr. Alex Christakis
*Center for Contemporary Problems*

## SESSION III—IMPLICATIONS OF ALTERNATIVE GROWTH POLICIES

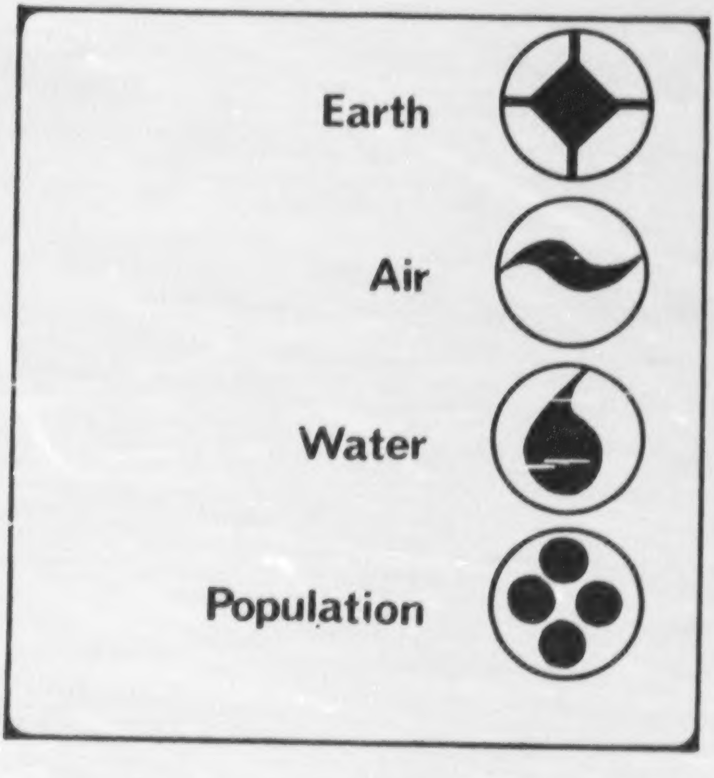
SOCIAL AND PRODUCTIVITY COSTS AND BENEFITS OF GROWTH POLICIES
Dr. Michael H. Moskow
*Department of Labor*

IMPLICATIONS OF SUSTAINABLE GROWTH
Chester Cooper
*Woodrow Wilson International Center for Scholars*

INTERNATIONAL IMPLICATIONS OF GROWTH POLICY
Dr. Lincoln Gordon
*Woodrow Wilson International Center for Scholars*

WHO PAYS FOR CHANGE AND HOW?
Dr. Carl Madden
*U.S. Chamber of Commerce*

HOW CAN/DO WE 'ACHIEVE AN EQUITABLE, COMPREHENSIVE NATIONAL GROWTH POLICY?
Dr. George Kozmetsky
*University of Texas*


Earth
Air
Water
Population